DOT HS-801 597

U.S. RESEARCH SAFETY VEHICLE (RSV) PHASE I PROGRAM- VOLUME II, PROGRAM DEFINITION FOUNDATION

Contract No. DOT-HS-4-00841
June 1975
Final Report

PREPARED FOR:

U.S. DEPARTMENT OF TRANSPORTATION
NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION
WASHINGTON, D.C. 20590

Document is available to the public through
the National Technical Information Service,
Springfield, Virginia 22161

TL 242 .A74 v.2

American Machine and Foundry Company.

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
DOT HS-801 597		

4. Title and Subtitle	5. Report Date
U.S. RESEARCH SAFETY VEHICLE (RSV) PHASE I PROGRAM, ~~Volume II,~~ V. 2, ~~Program Definition Foundation~~	June 1975
	6. Performing Organization Code
7. Author(s) J. Andon, E. Dodson, A. Khadilkar, R. Olson, L. Pauls, and W. Rup.	8. Performing Organization Report No. ASL-B31
9. Performing Organization Name and Address ~~AMF Incorporated~~ Advanced Systems Laboratory 495 South Fairview Avenue Goleta, California 93017	10. Work Unit No. (TRAIS)
	11. Contract or Grant No. DOT-HS-4-00841
12. Sponsoring Agency Name and Address U.S. Department of Transportation National Highway Traffic Safety Administration 400 Seventh Street, S.W. Washington, D.C. 20590	13. Type of Report and Period Covered FINAL REPORT Jan. 1974-April 1975
	14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

Current passenger car usage patterns and factors influencing usage are analyzed and projections of usage patterns in the mid-1980's are made. Similarly, current available data on six categories of vehicle accidents are analyzed and projections made of national accident patterns in the mid-80's; the effect of potential reductions in these projections as a result of safety programs and other factors related to driving safety are estimated.

Based on the usage and accident projections, the characteristics of an RSV (weighing under 3,000 lbs C.W.) for operation in the mid-1980 traffic environment are described.

A recommended set of specifications for the RSV are developed considering the potential safety payoff accruing to an increased level of safety performance, the need for energy conservation, availability of material resources, and changes in vehicle mix.

An executive summary of this report is presented in Volume I.

17. Key Words	18. Distribution Statement
Passenger car usage Vehicle accidents Projections of accidents in 1985 RSV specifications	Unlimited. Available through the National Technical Information Service, Springfield, Virginia 22161

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	427	

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

☆ U. S. GOVERNMENT PRINTING OFFICE : 1973 725-504/328

VOLUME II

TABLE OF CONTENTS (Cont'd)

VOLUME II

TABLE OF CONTENTS

VOLUME II

TABLE OF CONTENTS (Cont'd)

SECTION 3
PROGRAM DEFINITION FOUNDATION

The three elements comprising the program definition for the Research Safety Vehicle (RSV) are: a projection of transportation usage and other factors which bear upon the number and character of accidents to be expected in the 1985 time period; the projection of the accident environment that the RSV will encounter in the mid-1980's; the establishment of societal costs for the accident events that the RSV would encounter and the development of benefits attributable to the RSV design.

The methodology, analysis and data describing these three elements are presented in this volume of the final report.

3.1 TRANSPORTATION USAGE PROJECTIONS

3.1.1 Introduction

The purpose of Section 3.1 is to set forth transportation usage projections, together with the data and rationale upon which they are based. Section 3.2 of the report combines these usage projections with other information to develop accident forecasts.

Future transportation usage involves numerous considerations of both the demand for transportation and the availability of economic resources, fuel, vehicles, alternative modes of transportation, etc. Many of these are especially difficult to forecast at this particular time. However, it should be noted that, to a large degree, these considerations do not have a profound impact upon the overall usage picture in the mid-1980's. The total traffic environment is largely determined by overall economic and social factors which can be projected with reasonable confidence, i.e., most of the indicated elements of change and uncertainty represent minor perturbations

of these overall influences. For example, there is considerable uncertainty about future birth rates. Thus, future family size is difficult to forecast with the consequent uncertainty about demand for large family cars in the mid-1980's. However, the overall traffic environment will be largely determined by the size of the mid-80's driving population, all of whom have already been born, and thus can be projected to 1985 with confidence. Other examples are noted in succeeding sections which discuss the various factors contributing to transportation usage in the mid-80's.

Section 3.1.2 discusses future population and household characteristics. Sections 3.1.3 and 3.1.4 include a discussion of economic and transportation factors. A number of related but distinct factors bearing upon future automobile usage are considered in these sections. In the final section, all of these considerations are integrated within a single forecast.

These forecasts are based upon a variety of factors affecting the supply and demand of transportation. The first step in the general approach to forecasting is to identify the salient factors which bear upon future transportation usage. A major part of this investigation is a review of historical trends and patterns, carried out at a sufficient level of detail to discern key individual elements within this overall pattern of usage. Then, current and future developments and other factors which bear upon the likely continuation of these trends are considered.

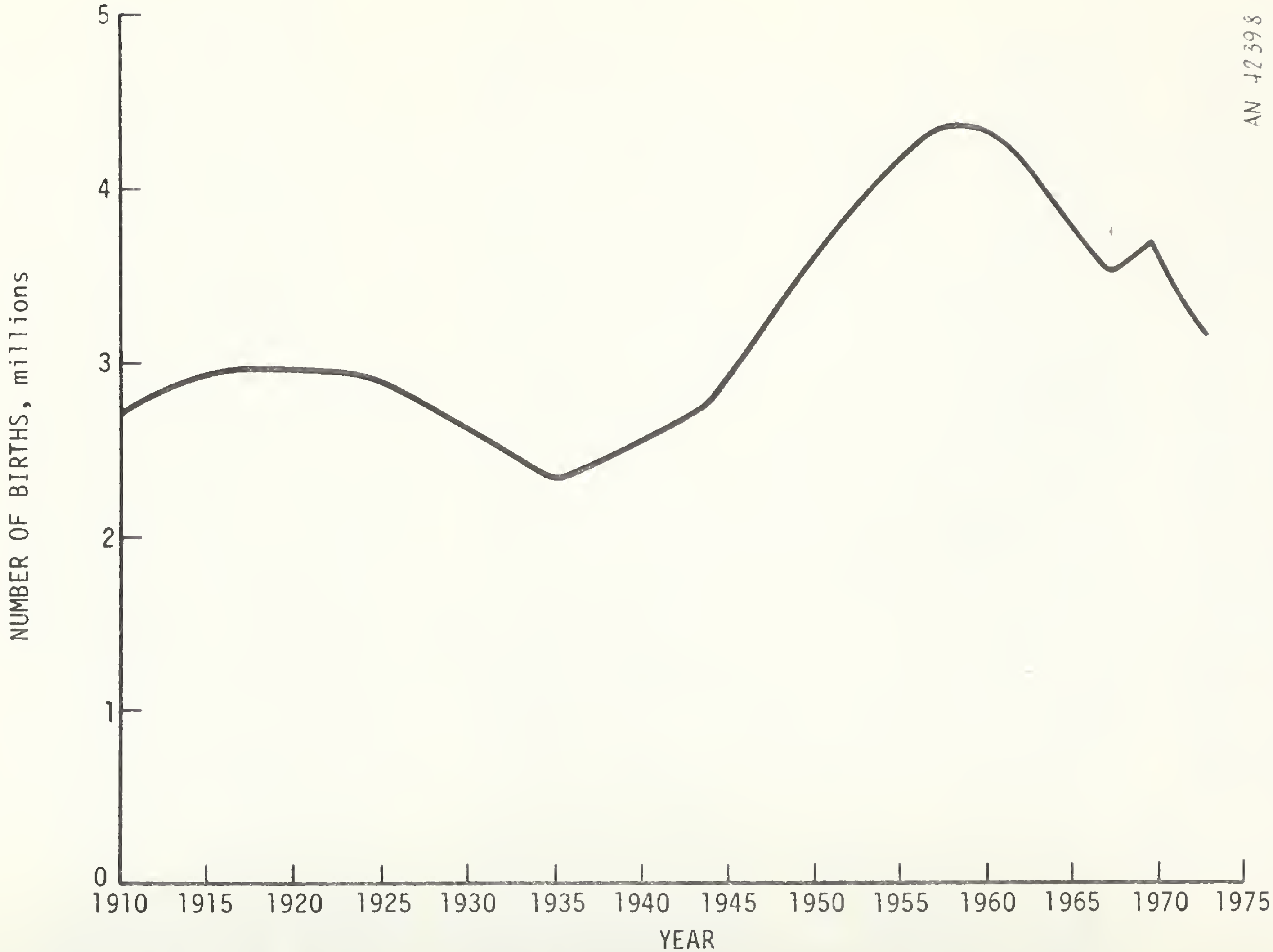
When there is a basic rationale underlying observed historical trends, and there are not current and future developments which indicate changes from past trends, forecasting can be carried out using mathematical techniques of regression analysis. These techniques can result in mathematical equations, or models, which provide an apparent rigor and quantitative "force" to forecasts. In this study, it was found that, in general, there are strong arguments against the use of these conventional mathematical techniques of time-series projections. Among the points militating against direct mathematical projections of transportation usage from historical data are the following:

- There have been great variations in birth rates, resulting in distinct differences in the size of particular age groups. As these groups progress through the age cycle, there are various disproportionate impacts upon future transportation usage.
- Historical patterns do not reflect effects of recent and pending changes in fuel costs, auto safety and air quality standards, the annual rate of inflation, housing patterns, and other factors discussed in the report.
- Very recent shifts in such factors as small car purchases and in percent of women who drive can be expected to reach saturation levels in the near future, i.e., they cannot be simply extrapolated.

The differences among age groups is considered fundamental in this study, and virtually all projections are made in sufficient detail to account for them. The various changes and saturation levels noted above, and others noted throughout the study, can only be appraised judgmentally. There is no purely objective, mathematical method of forecasting, say, future fuel prices and their impact on usage. The rationale for the subjective estimates that were made is given in the report.

3.1.2 Population and Household Characteristics

Population of Driving Age. The size and age structure of the United States' driver population in 1985 is closely related to the historic birth profile shown in Figure 3-1. Three features of the profile are especially [1] noteworthy: (1) an unusually low level of births during the depression/World War II years [1929-1945], (2) the post-war "baby boom", and (3) an unexpected sharp decline in births subsequent to 1970.



SOURCE: Historical Statistics, Colonial Times to 1957
Statistical Abstracts of the U.S.
Bureau of Census "P" Series Reports

Figure 3-1. U. S. Historic Birth Profile

Immigration, the other factor affecting the nation's population age structure, is regulated by legislation. The number of recent immigrants (averaging less than 300,000 per year for the past 40 years) and their age distribution do not materially alter the key variations noted in the birth profile.

As these key variations in birth trends progress through the age cycle, they appear as marked shifts in population patterns which, in turn, will have wide-ranging effects upon future transportation usage.

If one considers all persons over 15 years of age, representing the great preponderance of potential drivers, an increase of over 22 million (or over 14%) in this overall age group by 1985, as shown in Figure 3-2, will be experienced. It should be noted that projections to 1985 of those 15 and older are based upon births already recorded.

However, as indicated in Table 3-1, the bulk of this increase will be in the 25-44 age brackets, a group characterized by higher income production and increased transportation usage. In this period, the number of younger people (those under 24) actually declines as does the group born in the depression, i.e., those in the 45-55 age group, a group characterized by peak income and multi-car ownership).

It should also be noted that the 15-19 age group will decline even more sharply after 1985 when the effects of the declining birth rate of the seventies are felt.

Because of the marked differences in automobile purchases and usage (and accident rates) by the various age groups, these shifts in age structure preclude simple aggregate extrapolation of existing trends. Therefore, this study has been concerned primarily with specific age groups. The number and age of potential drivers, size of household, household income, and age of household head have been examined as factors to be considered in predicting transportation usage in the mid-1980's.

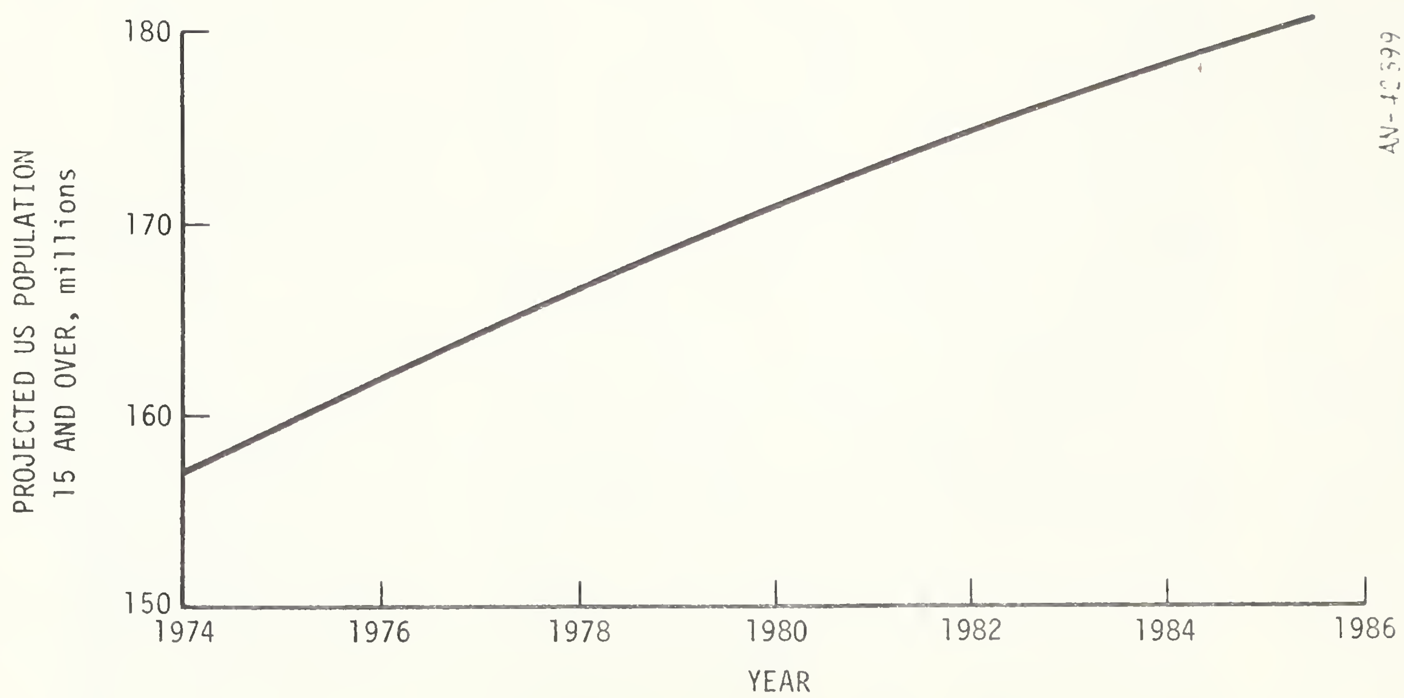


Figure 3-2 Projection of Potential U.S. Driving Population

Table 3-1

U.S. Population Projections by Age Groups (in thousands)*

Year	Age Groups							
	15-19	20-24	25-34	35-44	45-54	55-64	65-74	75 & Over
1974	20727	18968	29884	22670	23651	19580	13317	8407
1975	20943	19404	31114	22721	23563	19867	13549	8621
1976	21048	19800	32390	22937	23404	20143	13748	8798
1977	20959	20227	33529	23413	23137	20446	14010	8906
1978	20843	20583	34510	24127	22905	20667	14239	9059
1979	20649	20851	35652	24812	22631	20882	14460	9211
1980	20221	21067	36962	25370	22406	21083	14680	9371
1981	19651	21172	38326	26125	22225	21249	14875	9521
1982	19042	21085	38828	27452	22058	21375	15060	9659
1983	18376	20971	39544	28692	21965	21458	15242	9825
1984	17875	20780	40193	29941	21976	21434	15468	9992
1985	17668	20355	40841	31150	22036	21366	15725	10199

*Population estimates by age groups were extracted from Current Population Reports Series P-25, No. 493, which includes Armed Forces abroad and net immigration of 400,000 persons each year.

Driving Population. Not all the population of driving age actually drive. There are distinct variations among age and sex groups as far as the proportions of driving to non-driving population are concerned. Data from 1951-1972 was examined. Some historical trends are indicated in Table 3-2; the most recent data are shown in Table 3-3, and these are considered fairly representative of current drivers.

When considering the "institutional population" (i.e., those in prisons, hospitals, etc.), together with persons physically or mentally incapable of driving, and a significant number of non-drivers associated with large transit-oriented urban areas, it is felt that a proportion in the vicinity of 95% would be the saturation level for any group in future projections.

In examining past trends, the proportion of licensed drivers has increased in all age groups, with the increase in the proportions of female drivers particularly evident. When considering the availability of driver education and increases in numbers of women entering the work force, these proportions will continue to increase. Also, as women drivers progress through the age groups, they will increase the proportions in the older age groups by replacing those who never learned to drive.

In order to forecast the driver proportions by age and sex that could reasonably be expected in 1985, past and present driver distributions were analyzed, together with licensing limitations for the youngest age group, saturation limits among the intermediate groups, and a decline in physical capability as well as economic status after age 55. Also considered was the large number of females who live past normal driving age. These factors were combined using engineering judgment to derive the percentage figures given in Table 3-4. The driver proportions were then applied to the 1985 population projections to determine driver distribution by age and sex. The resulting number of 1985 drivers are compared with historical statistics regarding population and driver licenses in force in Table 3-5.

Table 3-2

Percent of Population Licensed as Drivers by Age and Sex for 1951-1956 and 1970

Age	Percent of Drivers					
	Males			Females		
	1951-1956	1970	% Diff.	1951-1956	1970	% Diff.
16-20	65.8	72.3	+ 6.5	31.6	57.9	+26.3
21-29	89.0	93.5	+ 4.5	50.6	77.1	+26.5
30-39	90.8	93.8	+ 3.0	53.8	75.9	+22.1
40-49	87.4	94.3	+ 6.9	46.8	73.4	+26.6
50-59	80.9	91.4	+10.5	32.3	58.0	+25.7
60-69	65.6	81.6	+16.0	18.2	42.4	+24.2
70 & over	37.8	61.8	+24.0	7.0	20.2	+13.2
All ages	78.3	87.0	+ 8.7	39.2	61.5	+22.3

Source: Nationwide Personal Transportation Study, Report No. 6, April 1973, Characteristics of Licensed Drivers, Federal Highway Administration, U.S. Department of Transportation.

Table 3-3

Proportions of Population Licensed as Drivers in 1972

Age	Male	Female
16-20	73.2	58.5
21-25	92.2	74.8
26-29	96.0	81.6
30-39	94.1	76.6
40-49	94.3	73.7
50-59	91.7	58.4
60 & over	73.2	32.1

Source: National Highway Needs Report, U.S. Department of Transportation.

Table 3-4

Projected 1985 Driver Distribution

Age	Population (10^3)			Driver Population (10^3)			% of Drivers	
	Male	Female	Total	Male	Female	Total	Male	Female
16-19	7,125	6,886	14,011	5,344	4,269	9.613	75	62
20-24	10,305	10,049	20,354	9,738	8,340	18,078	94.5	83
25-29	10,688	10,515	21,203	10,154	9,043	19,197	95	86
30-34	9,852	9,786	19,638	9,359	8,416	17,775	95	86
35-39	8,661	8,748	17,409	8,228	7,611	15,839	95	87
40-44	6,748	6,993	13,741	6,411	5,944	12,355	95	85
45-54	10,630	11,407	22,037	10,098	9,582	19,680	95	84
55-64	9,874	11,492	21,366	9,088	8,964	18,052	92	78
65 & over	10,386	15,537	25,923	7,478	9,012	16,490	72	58
TOTALS	84,269	91,413	175,682	75,898	71,181	147,079	90.07	77.87

Source: Current Population Reports, P-25, No. 493. Population projections include Armed Forces abroad.

Table 3-5

Historical Data and Projections for Population, Drivers, and Driver Licenses in Force

Year	Total Population (1) 10^3	Population (1) Age 15 & Over 10^3	% of (1) Population Age 15 & Over	Number of (2) Driver Licenses 10^3	Driver Licenses % of Total Population	Driver Licenses % of Population Age 15 & Over
1960	180,671	124,599	68.96	87,361	48.35	70.11
1965	194,127	134,580	69.33	98,496	50.74	73.19
1970	204,879	147,024	71.76	111,543	54.44	75.87
1973	210,373	154,655	73.51	122,594	58.27	79.27
Year	**Total Population (1) 10^3**	**Population (1) Age 15 & Over 10^3**	**% of (1) Population Age 15 & Over**	**Number of Drivers 10^3**	**Drivers % of Total Population**	**Drivers % of Population Age 15 & Over**
1985 (Projected)	Series E 235,701	179,341	76.09	147,079	62.40	82.01
	Series F 230,913	179,341	77.67	147,079	63.69	82.01

Sources: (1) Statistical Abstracts of the U.S.
Current Population Reports, Series P-25, No. 493
(2) Highway Statistics

Table 3-5 indicates total population forecasts made by the Census Bureau using two different fertility assumptions (Series E and Series F). The difference has no impact upon driver population, but does affect the projected number of children born after 1973. Thus, the two assumptions result in different numbers of potential victims of accidents as pedestrians and passengers. It is noteworthy that most recent birth statistics follow the Series F projection. The number of children corresponding to the Series F projection for 1985 are as follows:

Age Group	Population
Under 5 years	18,100,000
5-9 years	17,000,000
10-14 years	16,500,000

Household Characteristics. Automobile ownership patterns and travel patterns are highly dependent upon certain household characteristics including income, age of household head and size of household. Recent auto purchasing and ownership patterns as a factor of age of household head are shown in Figure 3-3 and Table 3-6.

Historically, the total number of U.S. households has been in- [2,3,8]
creasing as shown in Figure 3-4, reflecting population growth and more recently, changes in social patterns affecting the composition and structure of families. In particular, the trend toward smaller families and one person households, discussed in more detail in succeeding paragraphs, will be reflected in an increase in the growth of the total number of U.S. households as shown in Figure 3-4.

The average household size in the U.S. has been experiencing a steady decline as indicated in Figure 3-5. Recently, this decline has steepened due to low birth rates, increased divorce rates, and to the rapidly increasing number of one person households. The Bureau of Census characteristics for March 1973 are as follows:

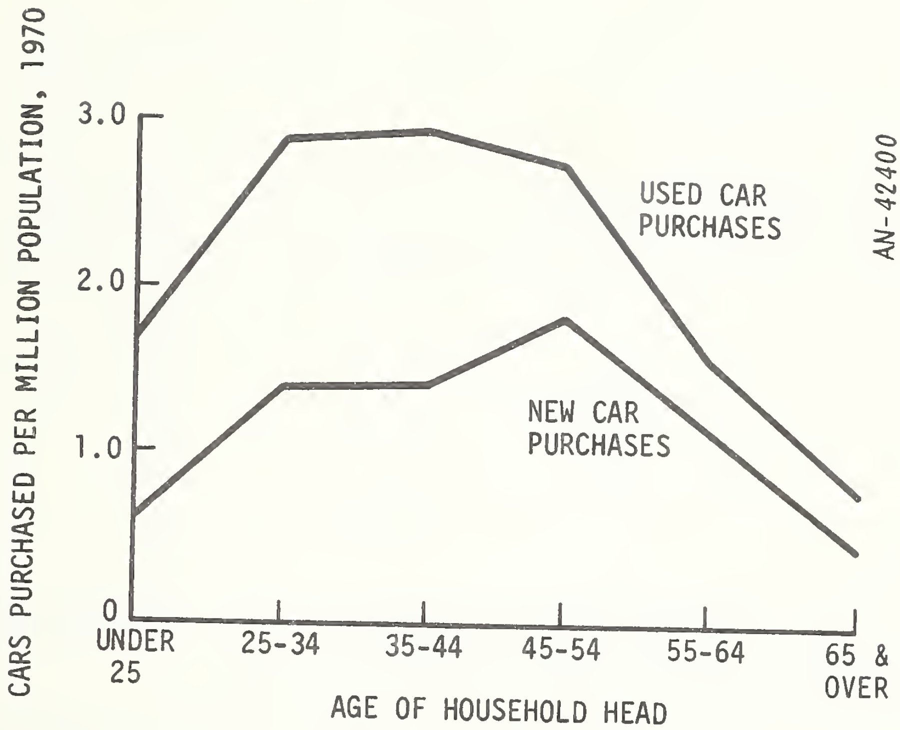


Figure 3-3 Auto Ownership by Age Group

Table 3-6
1971 Auto Ownership by Age of Household Head

Age of Household Head	No Car	One Car	Two Cars	Three or More Cars
Under 25	16.9%	62.8%	18.7%	1.6%
25-29	12.4	61.0	25.2	1.4
30-34	12.5	55.8	29.7	2.0
35-44	11.9	45.9	35.0	7.2
45-54	12.1	44.7	32.6	10.6
55-64	18.6	52.8	23.8	4.8
65 and over	45.4	45.2	8.3	1.1

Source: 1972 Automobile Facts and Figures, MVMA.

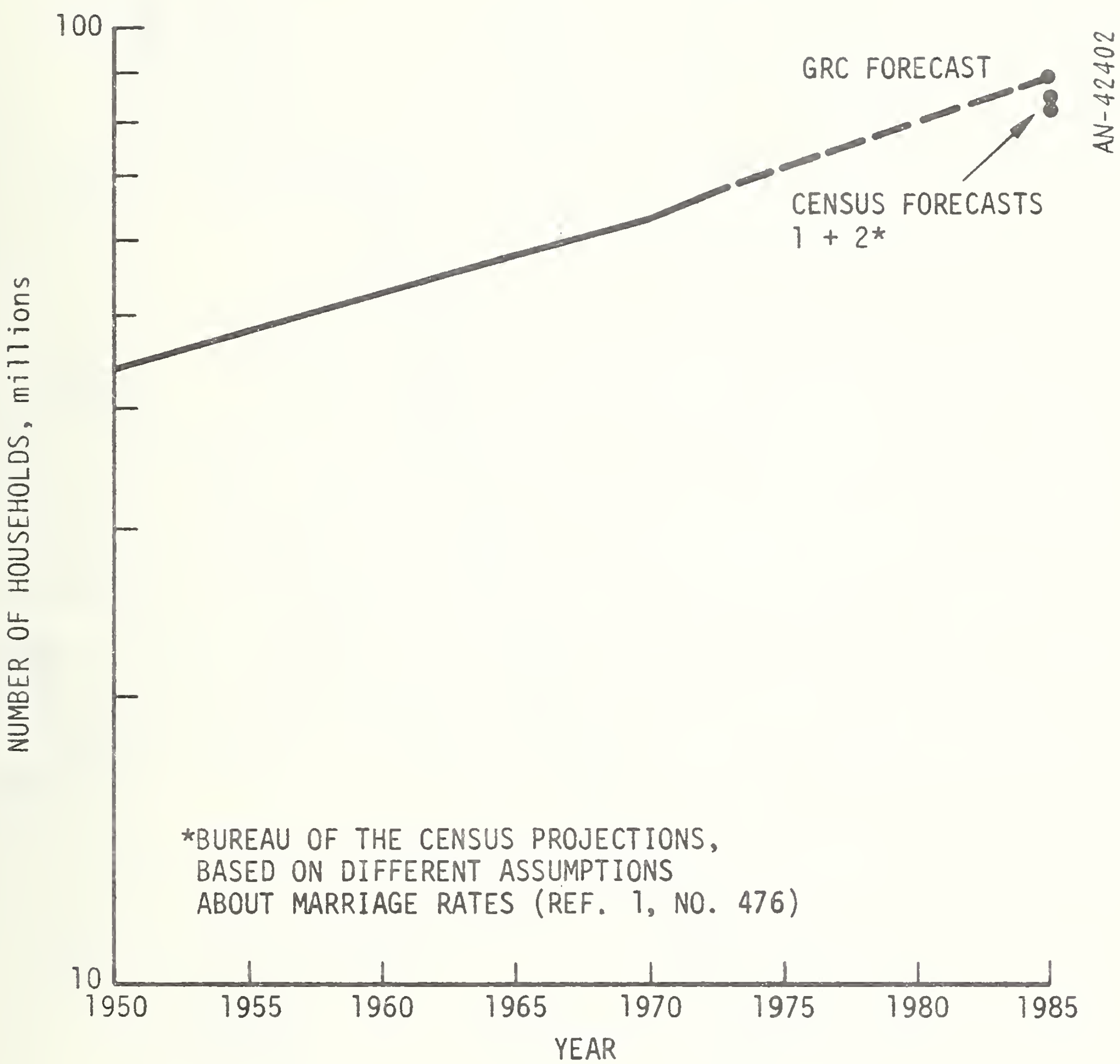


Figure 3-4 History and Projections of U.S. Households

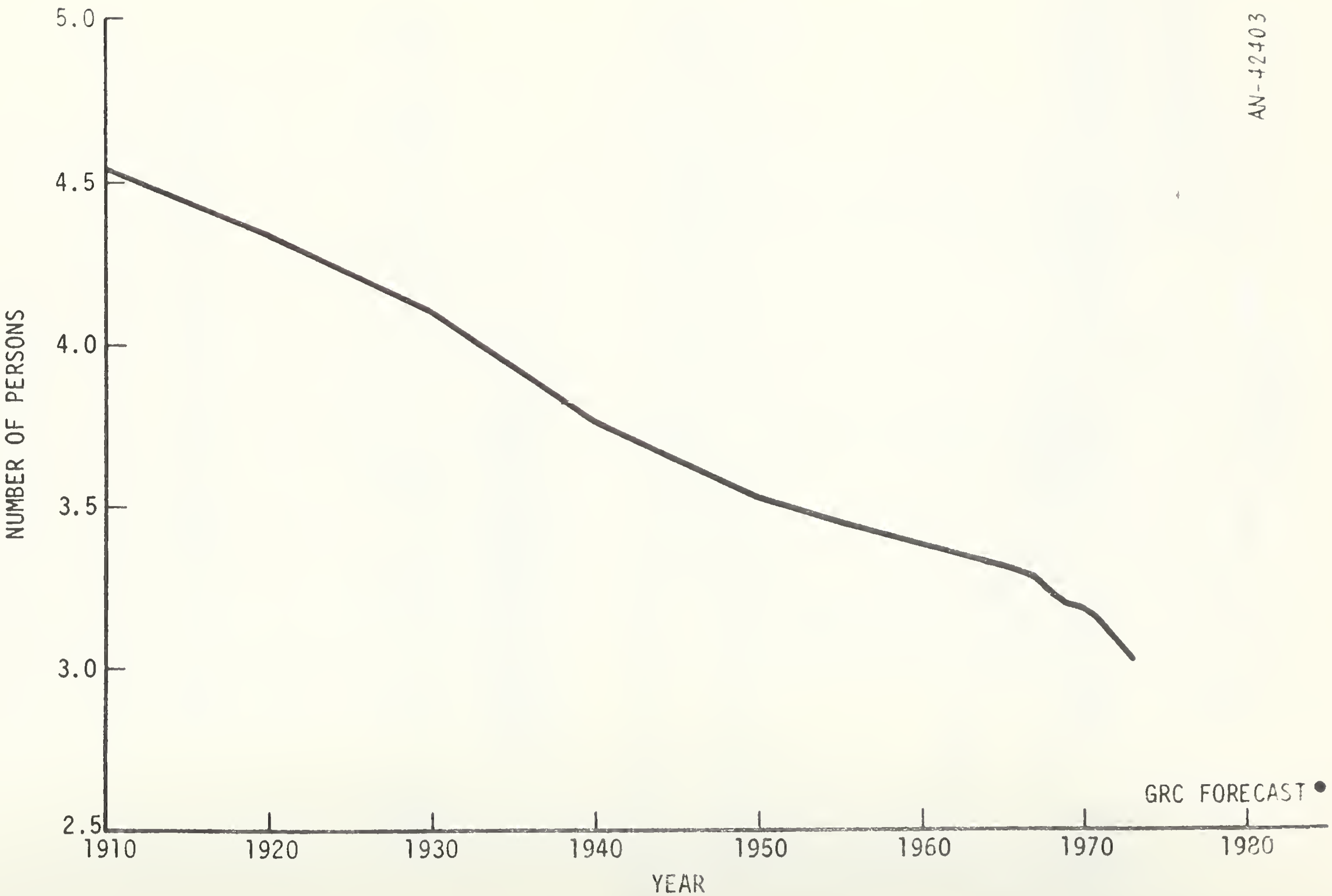


Figure 3-5 History and Projections of the Average Size of U. S. Household

Characteristics of Households by Type: (in thousands)

Size of Household		Age of Head	
1 person	12,635	Under 25 years	5,476
2 persons	20,632	25 to 29 years	7,116
3 persons	11,804	30 to 34 years	6,447
4 persons	10,739	35 to 44 years	11,721
5 persons	6,426	45 to 54 years	12,805
6 persons	3,245	55 to 64 years	11,212
7 persons or more	2,769	65 to 74 years	8,369
		75 years and over	5,104
TOTAL	68,251	ALL HOUSEHOLDS	68,251

As shown by the historical data in Figure 3-6, the decline in larger households is readily apparent, as is the increase in one person households. A continuation of these trends is forecasted, i.e., that the proportion of large families will continue to decline and the percentage of one person households will continue to grow as the peak of the "baby boom" children enter adulthood and as the number of older persons (widows, widowers, etc.) increase. By extending past and present trends in household formation, and considering the effects of marriage, divorce and birth rates, the following number of household by size and age of head are predicted for 1985:

Projected 1985 Characteristics of Household by Type: (in thousands)

Size of Household		Age of Head	
1 person	21,534	Under 25 years	7,328
2 persons	30,763	25 to 29 years	10,389
3 persons	17,139	30 to 34 years	10,409
4 persons	10,547	35 to 44 years	17,444
5 persons or more	7,910	45 to 54 years	12,561
		55 to 64 years	12,606
		65 to 74 years	10,221
		75 years and over	6,935
TOTAL	87,893	ALL HOUSEHOLDS	87,893

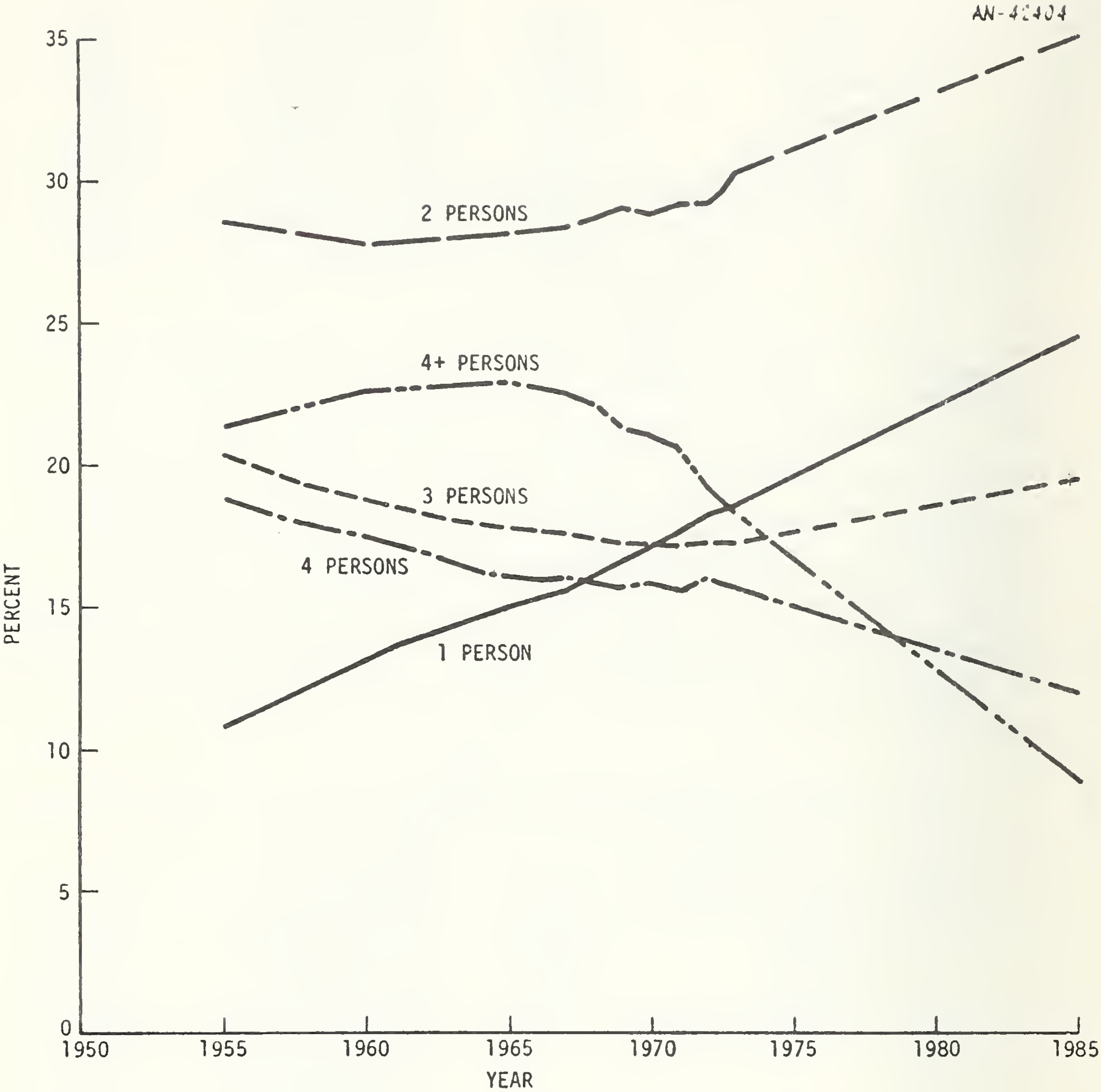


Figure 3-6 History and Projection of the Composition of U. S. Households

Not all the population is represented in households. Approximately 1.5% of the nation's driver population resides in "group quarters", i.e., college dormitories, military barracks, etc., and therefore are not included in household information. Practically all of these persons are in the under 25 age group and their car ownership and travel patterns are included in that group's predicted transportation usage. For clarification of definition of households and group quarters, see Statistical Abstract of the U.S. [3]

Car Per Household Ratio. As the number of household formations increases and the average household size continues to decrease, the present trend in ratio of cars per household will decline. As shown in Figure 3-7, this ratio has steadily increased from 1950 until recently when the rate of increased has slowed considerably.

It is expected that the car per household factor will continue its present modest rate of increase until the late 1970's because each year, larger number of "baby boom" children reach driving age while residing in their family household. By 1980, these children, for the most part, will have left their family households and will have established other household arrangements, thereby effecting the decline in the car per household ratio shown in Figure 3-7.

The number of households and the car per household ratio is one factor influencing future car usage. In the next sections, other factors are considered and then integrated to form a final projection of usage.

3.1.3 Economic Factors

Among the key influences upon future transportation demand are basic economic considerations, a major determinant of usage. Transportation has long been recognized as a vital element of the nation's overall economy, and analysts have explored at length the direct relationships between aggregate economic activity and the demand for transportation service.

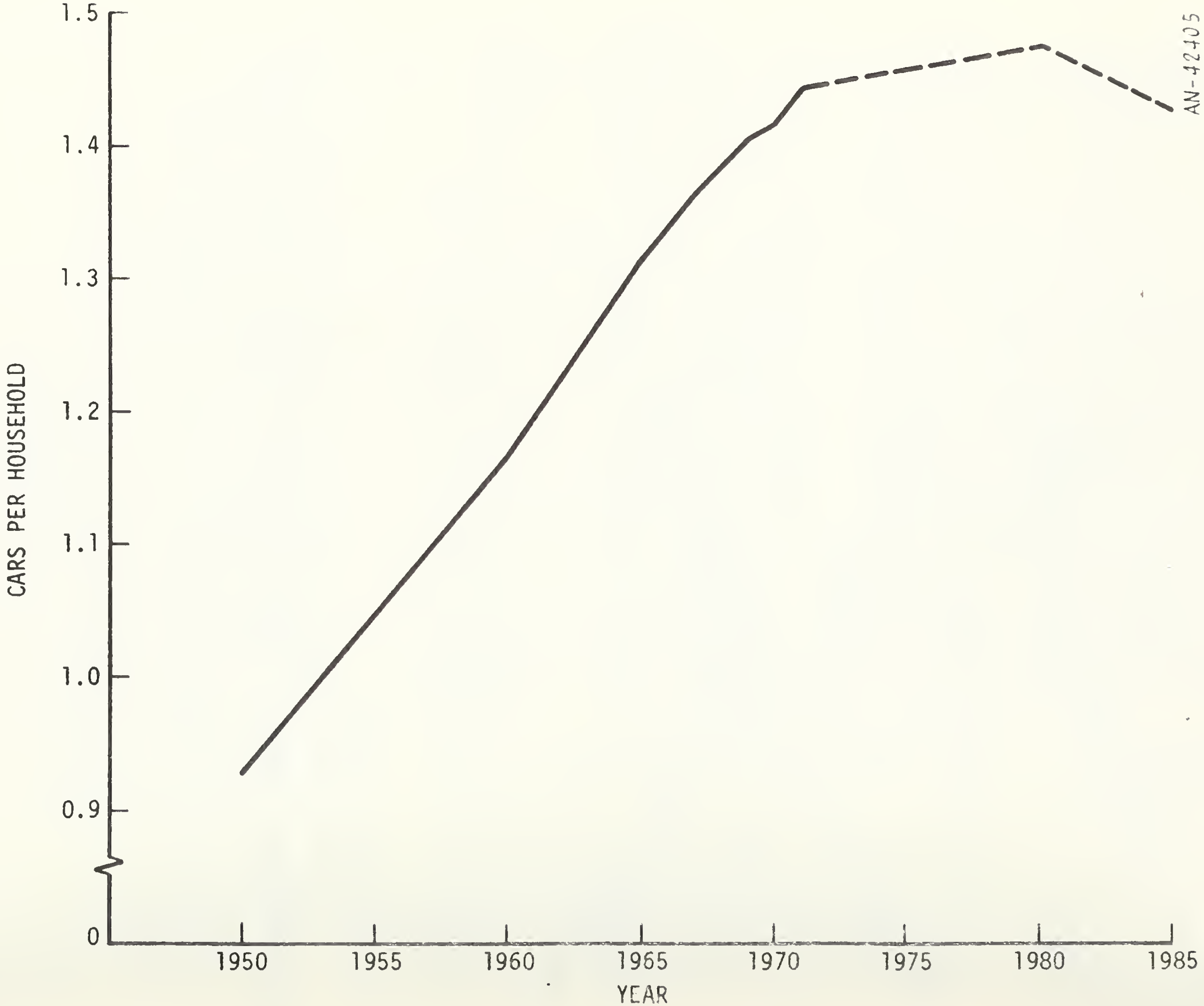


Figure 3-7 History and Projections of Cars Per Household

The forecasting of national economic trends is a complex undertaking where unpredictable political events can significantly alter annual forecasts of the national economic as evidenced by the current "double digit" inflation in the U.S. However, most of the variability in Gross National Product (GNP), the primary measure of aggregate economic activity, is in the government and private capital investment sectors. Personal consumption expenditures, the sector of most immediate interest for this study, has been much more stable over time, and is inherently more predictable (see Figure 3-8).

The shifts in age structure noted in Section 3.1.1 will result in a larger proportion of working age people within the nation's population, and will cause per capita income to increase. This, when coupled with the decline in birth rate (which will allow more wives to participate in the work force and lower the ratio of dependents to workers) will result in larger percentages of income available for discretionary purposes, i.e., for expenditures beyond basic food, clothing and household needs. Even if a relatively high rate of inflation persists, it is anticipated that growth in discretionary income, when measured in constant dollars, will allow continuance of growth in consumer demand for goods and services.

Within personal consumption are expenditures for consumer durables (such as refrigerators, autos, etc.). These exhibit some short-term variability, as shown in Figure 3-9, but still can be extrapolated with reasonable confidence based on long-term trends.

From Figures 3-8 and 3-9, it can be seen that consumer durable expenditures represent an increasing share of total personal consumption outlays. A major portion of consumer durable expenditures is for automobiles and automobile parts. Historical data are shown in Figure 3-10 (for comparative purposes, the time trend of total vehicle miles is also shown). These data show some year-to-year instability, which is common to many durable expenditures. The purchase of a car can be readily postponed;

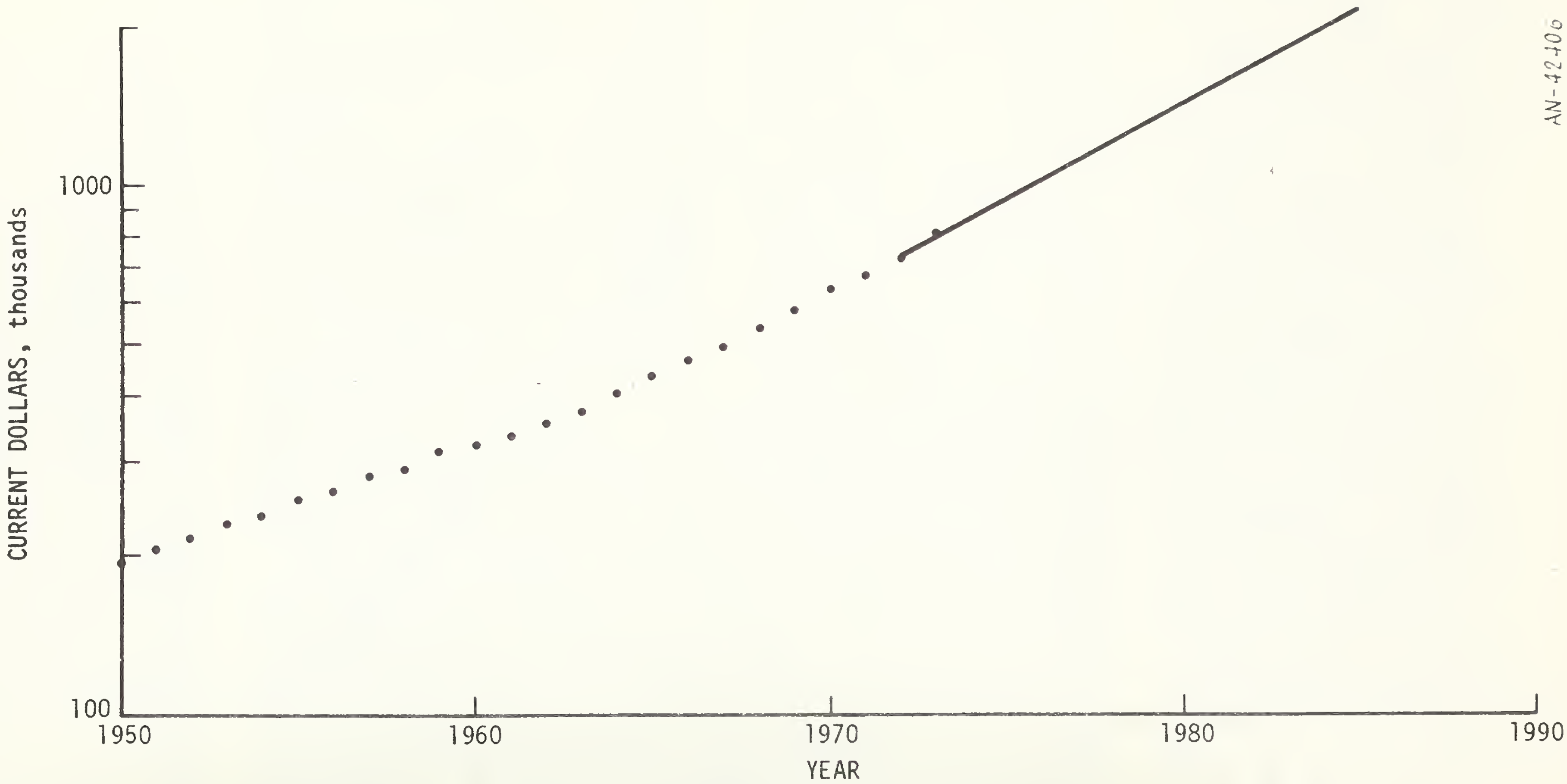


Figure 3-8 History and Projection of U.S. Personal Consumption Expenditures

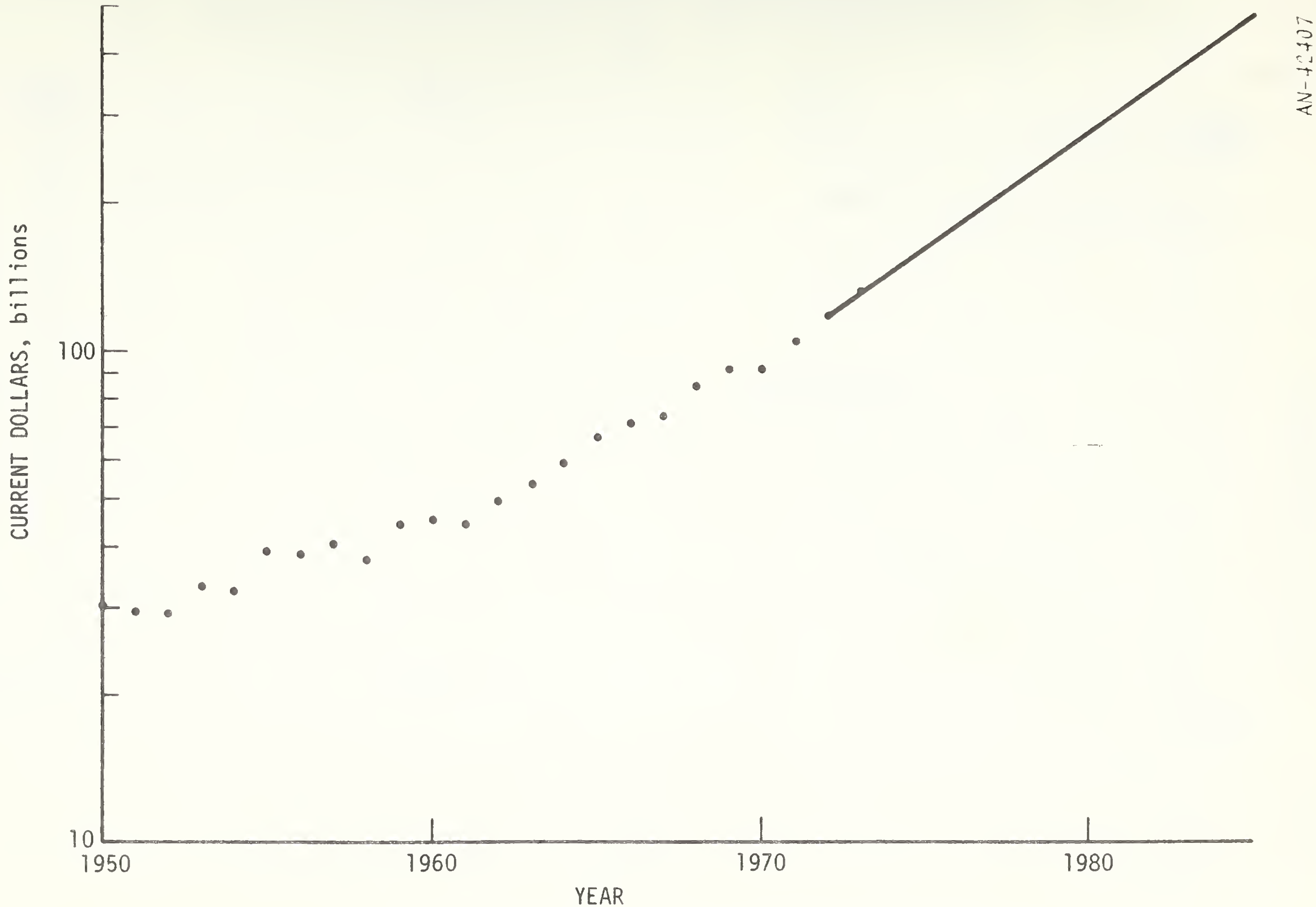


Figure 3-9 History and Projection of U. S. Expenditures for Consumer Durables

AN-42408

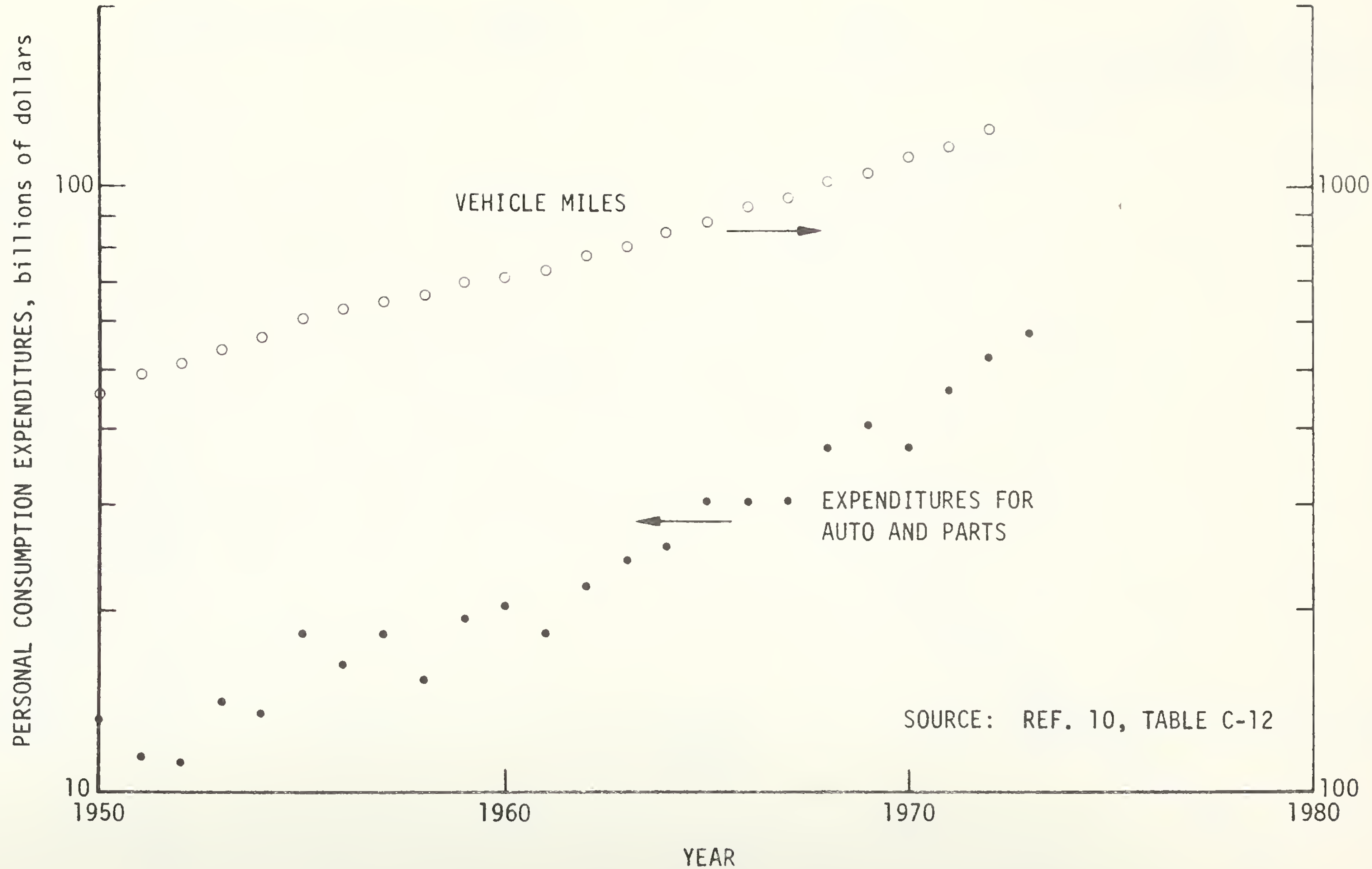


Figure 3-10 History of Personal Expenditure for Autos and Parts

however, over a period of a few years, the sale will generally be realized since the personal car is a need for a significant part of the population which depends on it as the only available transportation means.

Because of higher operating costs, some decrease in the rate of increase of expenditures for automobiles and parts is expected. The available information concerning the national average price paid for new and used cars up to March 1973 is shown in Figure 3-11. Thus, they do not reflect the impact of recent inflationary price increases which will alter the recent trends. Also, it is anticipated that current inflationary impacts will not extend to 1985 because of federally instituted programs and policies to be taken as counteractions.

3.1.4 Transportation Factors

The preceding discussions of demographic and economic factors have been primarily concerned with the demand for automobile transportation. In this section, various transportation factors bearing upon both supply and demand are considered. Governmental projections of the future highway and roadway system are discussed first. While some reductions in the projected highway programs are foreseen, these are not considered sufficient to be a significant constraint upon growth of transportation usage. A second discussion focuses upon modes of transportation which represent alternatives to the automobile. Prospective changes in the relative use of these modes are almost exclusively in urban areas. While the federal government is sponsoring numerous development and demonstration programs for new urban transit systems, it is felt that these will have little effect upon automobile usage in 1985.

Consideration is also given to other transportation-related considerations, i.e., gasoline prices, air quality standards.

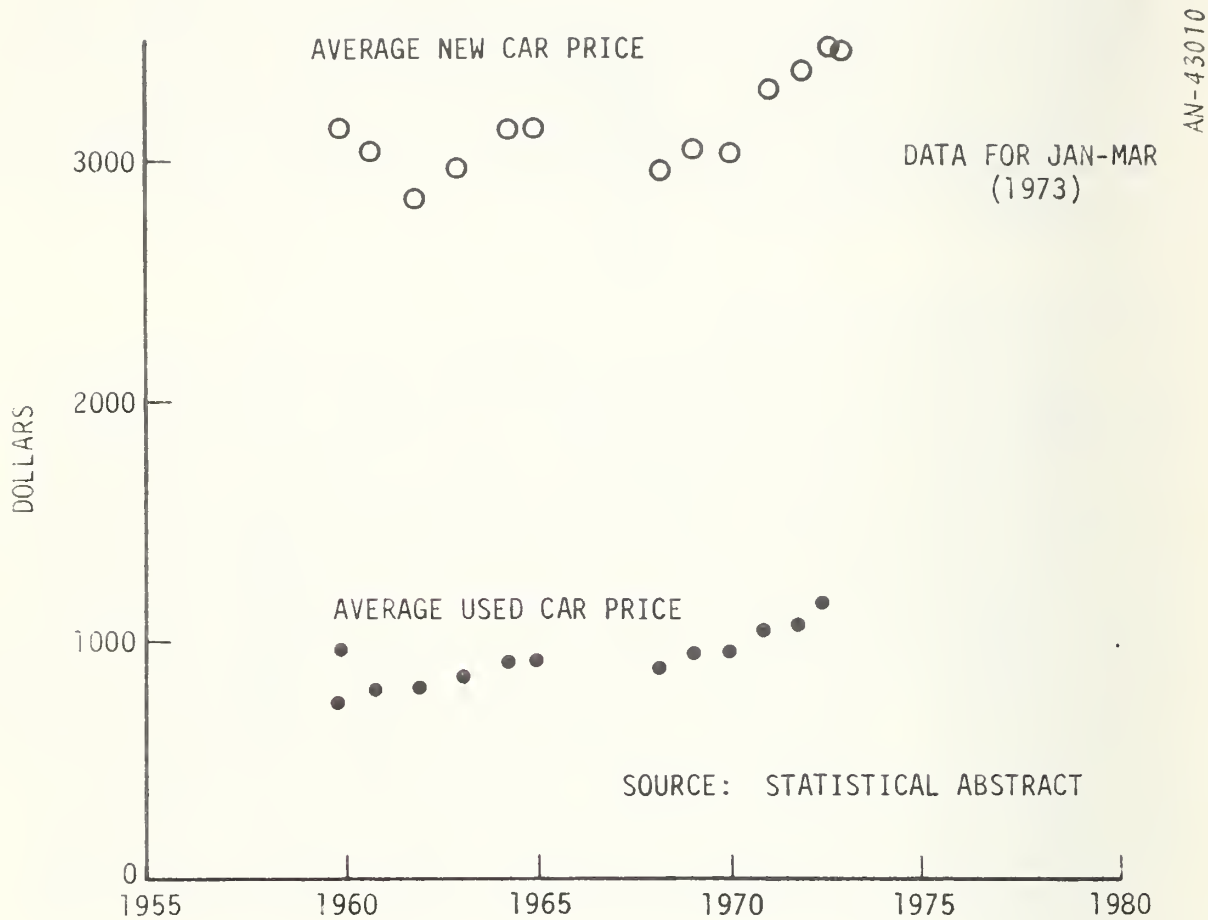


Figure 3-11 Recent Car Price Trends

The Future Highway Network. In its 1972 National Highway Needs Study, [6] the Federal Highway Administration (FHWA) has compiled and integrated state studies with regard to their present and future highway transportation needs. This FHWA report contains an extensive description of the current and projected U.S. highway system. In gathering, collating and reporting data, the FHWA utilizes the term "urban" solely in connection with federal-aid statistics that refer specifically to areas including and adjacent to municipalities or other urban places having a population of 5,000 or more. These federal-aid urban areas may extend beyond corporate boundaries and thus are not necessarily coextensive with cities or other municipal jurisdictions. Arterials are defined as roads that provide basically through-travel service, serve the longest trips, and have the heaviest traffic. Locals are those roads that provide primarily the land access function to abutting property. Collectors are intermediate between arterials and locals providing both through-travel and local access functions.

The study presents 1970 highway service structure data, together with projections to 1990, and recommends to Congress a Federal Highway Improvement Program designed to foster smooth traffic flow in the future. Tables 3-7, 3-8 and 3-9 summarize portions of this data.

Table 3-7. Highway System Linear Mileage (Millions of Miles)

Type	1970	1990
Urban:		
Arterials	0.10	0.17
Collectors	0.04	0.08
Locals	0.35	0.57
Subtotal	0.49	0.82
Rural:		
Arterials	0.28	0.29
Collectors	0.69	0.71
Locals	2.11	2.10
Subtotal	3.08	3.10
TOTAL	3.57	3.92

Table 3-8. Highway System Traffic (Billions of Vehicle Miles)

Type	1970	1990
Urban:		
Arterials	429	896
Collectors	46	90
Locals	102	134
Subtotal	577	1,120
Rural:		
Arterials	356	525
Collectors	121	158
Locals	66	67
Subtotal	543	750
TOTAL	1,120	1,870

Table 3-9. 1970 Highway Congestion Environment

	Percent Congested Arterials During Peak	
Urban Population	Major	Minor
1,000,000 plus	28%	12%
500,000 - 1,000,000	24%	12%
50,000 - 500,000	18%	7%
Under 50,000	9%	3%

It can be seen from Table 3-7 that while hardly any increase in rural mileage is projected, an approximate 66% addition to urban mileage is planned. This is consistent with the doubling of urban traffic projected for 1990 in Table 3-8. The relative amount of highway congestion, depicted in Table 3-9, shows the percent of arterial road mileage with peak-hour traffic congestion. Congestion is generally indicated when traffic is at least 85% of the road

capacity, which in turn is defined as the maximum traffic permitting an average speed of 35 mph on a given road. Predictably, Table 3-9 shows that peak hour road congestion falls off as both area population and road classification drop.

According to the study, and based upon the aforementioned urban population data and driving profiles, the FHWA estimates that 40% of urban travel occurs during traffic peaks and that 18% of the urban highway traffic during the commuter travel periods is subject to congestion that significantly affects driver-vehicle performance.

Since this FHWA study was made, there have been several developments which suggest that its forecasts may overstate future highway construction. Over the past several years, public resistance to freeway construction in urbanized areas has increased. There are now fairly rigorous requirements for environmental impact assessment prior to highway construction. The Clean Air Act also reflects a public concern about smog and a reluctance to proceed unquestioningly with urban highway expansion. Most recently, the energy crisis has had manifold impacts. Shortages and higher prices have led to reductions in highway trust fund accumulations, and to a growing emphasis upon public transit. Also, greater use of gas tax funds for transit is in the offing (but additionalfunds will be required to meet the growing deficit in transit operations). As discussed in another section, no significant diversion of automobile travel to transit usage is foreseen.

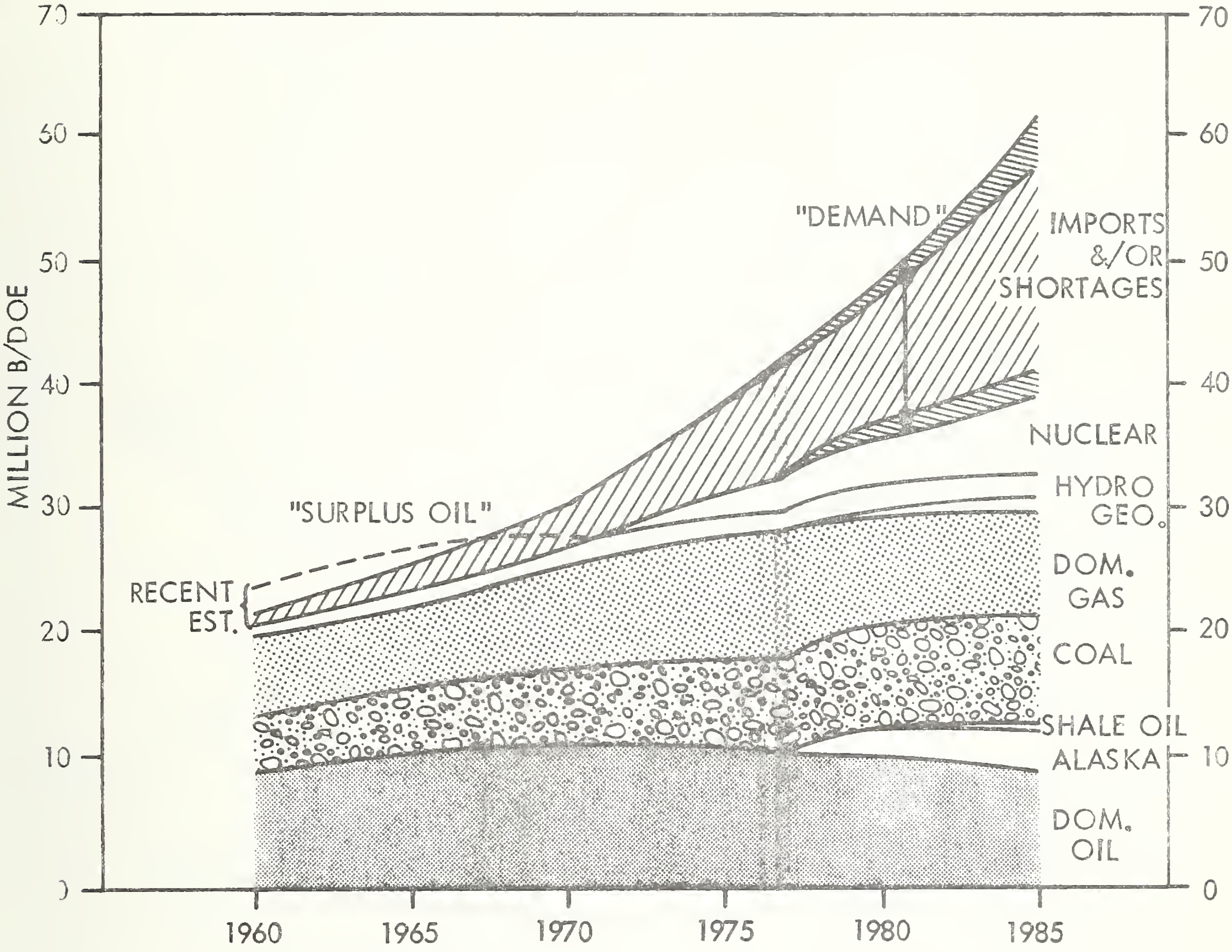
At this point, the effects of these various supply considerations cannot be set forth with any precision. A subjective evaluation is made that some reduction in FHWA projections of supply (i.e., highway construction) will not significantly affect usage.

Fuel Resources. The growing gap between the domestic demand for energy and the domestic supply of energy has been evident since the 1960's. Favorable pricing of imported energy, primarily crude oil from the mid-East countries, obscured this gap until recently since all domestic energy demands were met

at relatively stable and acceptable costs. In 1973, the seriousness of this gap was demonstrated when a political crisis in the mid-East resulted, not only in a temporary cutback of oil from these sources, but price increases of over 100% in the price of their crude oil. The 12 nation Organization of Petroleum Exporting Countries (OPEC), now wield a virtual monopoly as key suppliers of petroleum to the United States as well as other industrial nations in Europe and Asia. The future implications of U.S. dependency on imports is depicted in Figure 3-12 which projects the total U.S. demand for energy and the total domestic energy supplies from all sources. The source data for these projections was a study conducted by the Joint [9] Congressional Committee on Atomic Energy for the Congress.

In 1970, 95% of the energy required for transportation came from oil (petroleum) and about 53% of the oil supply in the U.S. was used for transportation, 22% of which was imported. In 1985, imported oil is projected to constitute approximately 57% of the total U.S. supply. For passenger cars, which consumed 55% of all transportation energy in 1970, the 1985 projections of oil sources have significant implications in terms of the [10,11] cost per gallon, if not outright shortages.

Alternative energy sources have been suggested as solutions to decrease the dependence of the automobile on petroleum products. Unfortunately, energy consuming sectors, other than transportation, are faced with the same basic shortages and will therefore compete for these alternatives, primarily gases and electricity (which is derived from basic energy sources). Figure 3-13 presents the recent and projected patterns of energy demands by competing consumer sectors. The projected patterns indicate that the relative demand ratios by consuming sectors will be essentially the same as past and current patterns, but the energy demand rate will continue to increase. It is anticipated that the historical economic forces, in the face of increased demand and declining supply, will result in increasing costs of energy, regardless of source, into the mid-80's. Beyond the 1980 decade, increased



* B/DOE = BARRELS/DAY OF OIL EQUIVALENT

Figure 3-12 U. S. Total Energy Supply/Demand (Late '72 Data)

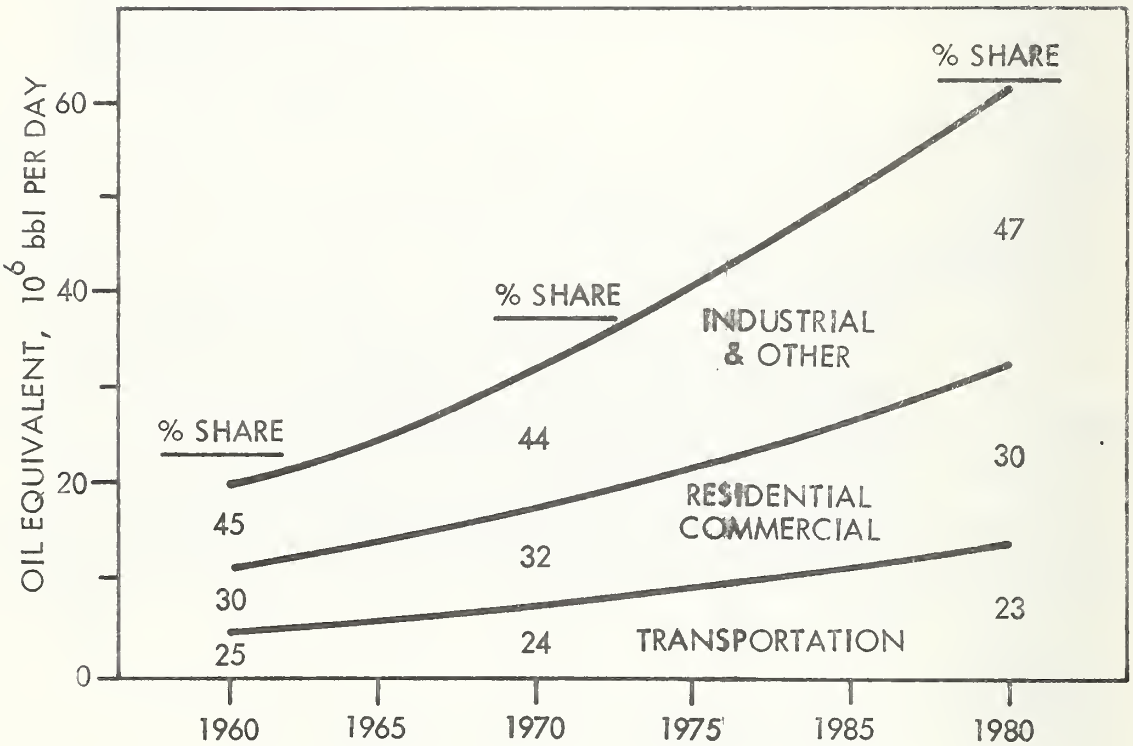


Figure 3-13 U. S. Energy Demand by Consuming Sectors

use of nuclear energy and the development of new energy sources (solar, geothermal, organic) should stabilize, if not reverse, the near-term trends of supply and demand.

The uncertainties associated with future considerations related to energy resources (OPEC's policies on production and pricing, the global demand for their supplies, and the progress of the U.S. programs for energy self-sufficiency) precludes any quantitative projections of the availability and costs of automotive fuels in the mid-80's. However, qualitative assessments can be made of the probable major impact of total energy projections on the automotive sector; these include the following:

1. Costs of automotive fuel will be significantly higher than current levels. The increase may result from the imposition of higher taxes designed to constrain fuel usage and to fund energy-related programs as well as the increased costs of imported fuel and fuel from new domestic sources.

2. Costs of all fuels will have a collateral effect on the raw material, fabrication, assembly, and finishing costs of automobiles, or on the availability of raw materials and parts.

In terms of usage, the effect of higher auto and fuel prices will most influence the economically marginal segments of the car buying and using population. For the majority of the driving population, the car will remain a necessity for business and personal use although with probable decreases in its non-essential uses and a preference for smaller, more economical (first and running costs) models. The usage forecasts anticipate relatively modest effects of higher fuel prices especially when the alternatives to the car are assessed as a transportation means.

<u>Alternative Modes of Transportation</u>. Another consideration bearing upon future automobile usage and accidents, is the future use of alternative modes of transportation. The most notable prospects are the various forms of urban transit.

For over half a century, the U.S. population has migrated from rural portions of the country to the cities and then from the central cities to the suburbs. As a result in 1970, 74% of the nation's population resided in its cities and their surrounding suburbs. This general trend (shown in Figure 3-14) has been forecast to continue, so that by 1990, 82% of the population will be living in urban areas. [14]

There have been some recent indications of a slowing and even short-term reversal of this trend. Recent economic conditions, including increases in farm prices, are thought to underlie these observations. However, it is anticipated that the basic urbanization trend will continue. It should be noted that in most federal reports, urban areas are defined to include relatively small towns, i.e., they include areas of more than 5,000 people (in some reports, such as shown in Figure 3-14, the definition is more than 2,500 people).

Increasing urbanization and income have resulted in more travel and greater pressure on existing urban transportation systems. During the sixties, significant changes occurred in the pattern of urban travel, with large increases in automobile travel and corresponding decreases in public transportation level. Between 1960 and 1970, urban automobile travel increased about 74%, to 737 billion passenger miles annually (see Table 3-10). Taxi travel increased about 31% during the same time period, urban bus transit decreased about 8%, and commuter rail travel remained relatively stable.

In effect, urban passenger travel by automobile has increased from 88% of all urban travel in 1960 to nearly 94% in 1970. Clearly, automobiles absorbed most of the growth in urban travel during the sixties, diverting many passengers from mass transportation.

Recent figures published by the American Transit Association indicate a continuing decline in public transit use in the early seventies. Table 3-11 shows the trend of total passengers and revenue passengers carried by the [18] approximately 250 local motor bus and rail transit systems the Association represents. Total passenger figures include revenue (public) passengers,

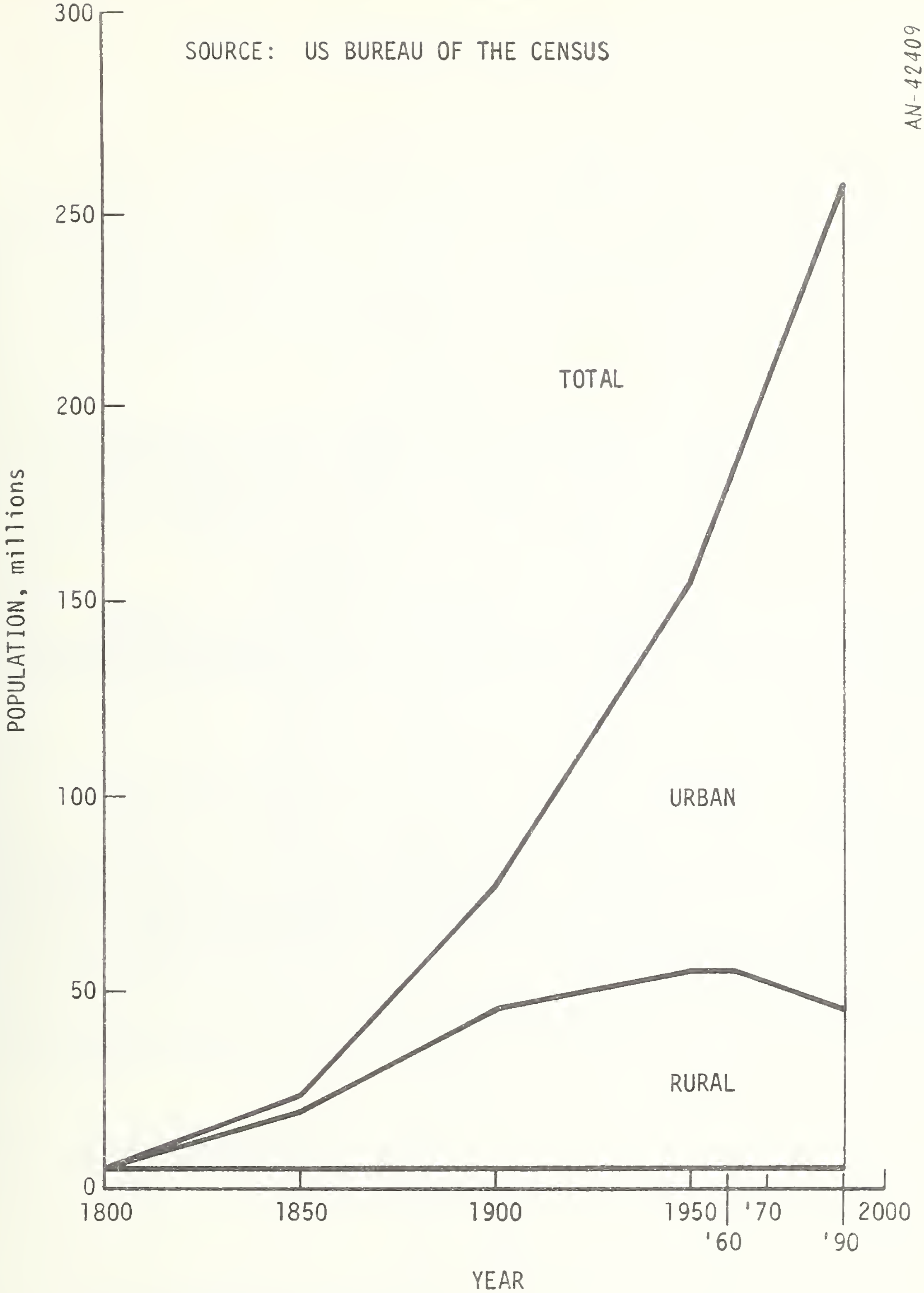


Figure 3-14 Urban and Rural Population of the United States, 1800-1990 (Urban includes all persons in urban areas of 2,500 or more)

Table 3-10

Urban Passenger-Miles by Mode, 1960-1970 [15, 16, 17]

Mode	1960 Passenger-Miles of Travel (millions)	1960 Percent of Total	1970 Passenger-Miles of Travel (millions)	1970 Percent of Total	Percent Change
Automobile	423,300	88.4	736,689	93.9	74.0
Bus Transit*	28,328	5.9	20,864	2.7	-26.3
Rail Transit**	18,504	3.9	16,928	2.2	- 8.5
Commuter Rail	4,600	1.0	4,600	0.6	0.0
Taxicabs	3,900***	0.8	5,100	0.6	30.8
Total	478,600	100.0	784,207	100.0	63.8

*Includes trolley coaches.
**Includes surface railway.
***Estimated.

Table 3-11

Trends of Total and Revenue Passengers on U.S. Transit Lines

Calendar Year	Railway			Trolley Coach (Millions)	Motor Bus (Millions)	Grand Total (Millions)
	Surface (Millions)	Subway & Elevated (Millions)	Total (Millions)			
TREND OF TOTAL PASSENGERS						
1960	463	1,850	2,313	657	6,425	9,395
1961	434	1,855	2,289	601	5,993	8,883
1962	393	1,890	2,283	547	5,865	8,695
1963	329	1,836	2,165	413	5,822	8,400
1964	289	1,877	2,166	349	5,813	8,328
1965	276	1,858	2,134	305	5,814	8,253
1966	282	1,753	2,035	284	5,764	8,083
1967	263	1,938	2,201	248	5,723	8,172
1968	253	1,928	2,181	228	5,610	8,019
1969	249	1,980	2,229	199	5,375	7,803
1970	235	1,881	2,116	182	5,034	7,332
1971	222	1,778	2,000	148	4,699	6,847
1972	211	1,731	1,942	130	4,495	6,567
P 1973	207	1,714	1,921	97	4,642	6,660
TREND OF REVENUE PASSENGERS						
1960	335	1,670	2,005	447	5,069	7,521
1961	323	1,680	2,003	405	4,834	7,242
1962	284	1,704	1,988	361	4,773	7,122
1963	238	1,661	1,899	264	4,752	6,915
1964	213	1,698	1,911	214	4,729	6,854
1965	204	1,678	1,882	186	4,730	6,798
1966	211	1,584	1,795	174	4,702	6,671
1967	196	1,632	1,828	155	4,633	6,616
1968	187	1,627	1,814	152	4,525	6,491
1969	183	1,656	1,840	135	4,335	6,310
1970	172	1,573	1,746	128	4,058	5,931
1971	155	1,494	1,649	113	3,735	5,497
1972	147	1,454	1,602	100	3,569	5,271
P 1973	145	1,438	1,583	75	3,687	5,345

P=Preliminary

free riders (e.g., public employees, policemen), transfer riders, and charter riders (e.g., riders paid for by contract for a specified time period). The slight upsurge in the preliminary estimates for 1973 are probably attributable to the fuel shortage in the last quarter of the calendar year.

- Characteristics of Urban Travel

The thrust of transit development is concentrated in urban areas. Urban travel has several characteristics which must be considered in assessing likely urban transportation alternatives for the 1985 time period.

Trip Purpose

About 50% of all public transit trips are work-oriented, in contrast to 25% of auto trips (see Table 3-12). The second most important purpose [19] for which transit trips are made is school travel; collectively work and school transit trips constitute 65 to 70% of all transit trips. Because of the low use of public transit for non-work purposes, transit trips constitute a small fraction of total trips. Work is the predominant purpose for taxi trips; personal business is second in importance. Together these two purposes account for about 50% of all taxi trips.

Overall, the distribution of travel by purpose has changed over time. Work travel has been declining, while social, recreational, and shopping travel has been increasing (see Table 3-13). The data shown are from Detroit; similar figures are available from other cities. The data are considered representative of general usage. These trends will probably continue into [8] the future, i.e., non-work travel will increase at a faster rate than travel for work purposes.

Peaking

Urban travel exhibits a marked peaking characteristic which results from the American work-home pattern. Public transit trips in particular are becoming increasingly peaked. For example, peak-hour commuter railroad trips

Table 3-12

Trip Purpose by Transit and Automobile

Trip Purpose Category	Trips Made by Transit		Trips Made by Automobile	
	Trips	Percent	Trips	Percent
Home-Based Work*	154,000	47.5	854,000	27.0
Home-Based Shopping	30,000	9.3	486,000	15.4
Home-Based Personal Business	31,000	9.6	647,000	20.4
Home-Based Social	20,000	6.2	338,000	10.8
Home-Based Recreational	4,000	1.2	91,000	2.9
Home-Based School	60,000	18.5	129,000	4.1
Subtotal	299,000	92.3	2,545,000	80.6
Non-Home-Based	25,000	7.7	614,000	19.4
Total	324,000	100.0	3,159,000	100.0

*A Home-Based trip has either its origin or destination at home. Trips from home to work and back again count as two Home-Based work trips.

Table 3-13

Detroit Urban Travel by Purpose

Trip Purpose Category	1953		1965		Percent Increase 1953-1965
	Daily Trips	Percent	Daily Trips	Percent	
Work	2,481,000	38.8	2,655,000	27.0	7.0
Shopping	869,000	13.6	1,681,000	17.1	93.4
Social-Recreational	1,457,000	22.8	2,341,000	23.8	60.6
Other	1,585,000	24.8	3,156,000	32.1	99.1
Total	6,392,000	100.0	9,832,000	100.0	53.8
City Population	2,969,000		4,400,000		48.2

typically account for 20 to 25% of total daily travel (see Figure 3-15); for rail rapid transit, 15 to 20% occurs during peak hours; and for buses, peak hours handle 10 to 15% of daily travel. The peaking phenomenon creates major problems in terms of equipment and operators required to transport peak hour passengers. As a result, the transit system sized for peak loads is under-used, a condition that causes a revenue-cost squeeze which impacts transit system profitability and viability. These two considerations constitute continuing restraints upon expanded use of public transit. Increases in the more widely scattered and flexibly scheduled social, recreational, and shopping trips places transit travel at a continuing disadvantage, and peaking results in continuing profitability problems. [20,21,22]

Characteristics of Urban Travelers

The mode, type and amount of urban travel is directly related to the characteristics of urban travelers, and urban travel can be expected to change as these characteristics change. Personal income greatly influences the mode and number of trips by travelers. When income becomes greater, the number of shopping, social-recreational, and personal business automobile trips made by a typical household increases and the number of transit trips decrease (see Table 3-14). Because continued increases in personal income [23] are projected, conventional transit will continue to have patronage problems.

- Projected Urban Transportation

Increasing population and income are producing and will continue to produce, if current trends continue, large increases in urban travel. Non-work related travel is increasing faster than travel for work purposes. Because urban area expansion increases trip distances, improvements in the capacity of urban transportation systems will have to be made to accommodate urban travel growth.

Urban travel is determined by the characteristics of the traveler and the quality and availability of alternative transportation modes.

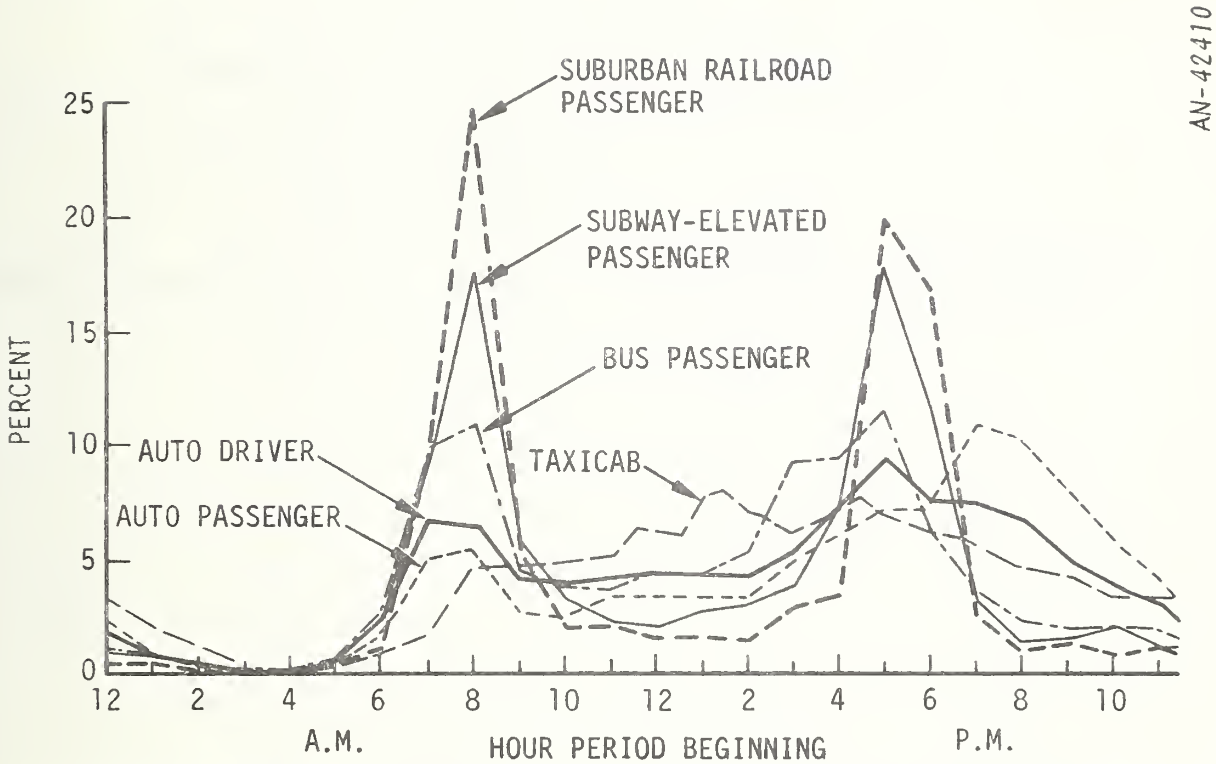


Figure 3-15 Distribution of Urban Travel by Time Day and Mode

Table 3-14

Urban Travel Related to Household Income, Milwaukee

Median Household Income (Dollars)	Percent of Households	Average Daily Number of Trips per Household		Percent by Transit
		All Trips	Transit Trips	
0-2,000	11.5	1.8	0.6	33.9
2,000-4,000	11.9	3.7	0.9	24.1
4,000-6,000	23.7	6.4	0.8	11.9
6,000-8,000	25.4	8.3	0.7	8.4
8,000-10,000	14.3	10.0	0.7	7.0
10,000-12,000	6.7	1 .0	0.7	6.0
12,000-14,000	2.5	11.2	0.6	5.3
14,000-16,000	1.4	11.8	0.5	3.8
Over 16,000	2.6	12.3	0.4	3.4
All Households	100.0	7.0	0.7	10.0

In order to achieve a significant and long-term diversion of traffic from passenger cars, an alternative mass transportation system must: (1) service the urban/suburban areas where no public transportation now exists, and (2) where public transportation exists, service must be enhanced to the point where it approximates the characteristics of the private automobile in terms of comfort, privacy, availability, and cost. Failure to satisfy these criteria in the past has resulted in the decline in public transportation in favor of the auto.

A number of major metropolitan areas have new or planned mass transportation systems which recognize the service requirements and have the potential of influencing usage patterns in the mid-80's. The following is a summary description of these systems.

Bay Area Rapid Transit (BART). A 75 mile train system, started in 1953, was intended to be self-supporting once capital costs were met. The system is now in partial operation and is scheduled to be in full operation by 1975. Inflation and rising operating costs have resulted in deficits which require state and federal subsidies. Increased fares to cover deficits were considered to be impractical and undesirable. Since the system is not fully operational, there is no evidence of its success in reducing automobile traffic. [24]

Denver Metro Transit (DMT). Six privately owned bus systems were taken over by the DMT and consolidated into an expanded single area-wide system. This system, financed by a bond issue and federal funding, resulted in an annual growth rate in ridership of 15% (since 1971) as opposed to a national rate of 2%. The system operates at a deficit, made up by increased sales taxes. The success of the bus system led to the approval of a $425 million bond issue in 1973 to partially finance a Personal Rapid Transit (PRT) system. A $28 million pilot PRT demonstration project,

funded by UMTA, is scheduled to be constructed in late 1974. Construction of a PRT system with a 6,000 passenger/hour capacity, to start in 1976, is contingent on successful demonstration of PRT technology and the receipt of $850 million of federal grants to supplement the local bond funds. [24]

Southern California Rapid Transit District (RTD). The RTD encompasses Los Angeles (city and county) and parts of Orange County. A planned rail-busway network system was defeated by voters in the November 1974 general election. Four alternatives to the rail-busway network are currently being proposed for long-term consideration. These alternatives are based on fixed guideway (rail) systems in networks ranging from 33 miles to 121 miles. All alternatives require substantial federal funding to support multi-billion dollar costs. Prior to the November 1974 general election, Arthur D. Little Inc. (ADL) was commissioned by the RTD to study the impact of the planned rail-busway system (including a rail network) on congestion, travel costs and time, and other community considerations. The report found that automobiles will continue to be the primary source of mobility in metropolitan Los Angeles in 1990. The biggest benefit to the average motorist switching to the system to get to work would be a saving of $1,100 per year and lessened commuting time. No estimates were made of any anticipated reductions in vehicles on the road, congestions, or other usage related factors. [25]

Washington Metropolitan Area Transit Authority. This agency is responsible for developing the Metro system, a 98 mile rail system to provide mass transportation for the District of Columbia and limited regions of Virginia and Maryland. In 1970, the estimated cost of this system was $2.5 billion with an additional $60 million in interest cost during construction. The financing of the costs included $835 million of revenue bonds, $1.47 billion in federal grants and the remainder in local grants apportioned to the regions serviced. The first leg of Metro was scheduled to be operational

in 1972; however, construction delays were encountered and the first of six operational phases is now scheduled for June 1975 and the last phase in December 1979. It is anticipated that as a result of these delays, the loss in fare revenues to service the bond issue and the related stretchout in construction and financing costs will require additional capital outlays. Metro planners anticipated a diversion from automobile travel for work purposes and estimates were made of the resulting cost savings (benefits) for motorists using the Metro, motorists not using the Metro, bus riders, and the business community. (Data on the corresponding reductions in vehicles on the road were not published.) Significantly, the greatest estimated benefits accrue to former bus riders ($82.9 million in 1990), with motorists using the Metro receiving the second largest benefit ($58.3 million). [26, 27]

Some estimates from sources other than the transit agencies, are available for the anticipated use of new systems: BART - 2-1/2% of trips in its area; RTD - 5%; and the Toronto, Canada, now in operation, 3 to 4%. Table 3-15 presents the transit usage in 1970 for a number of selected metropolitan areas in the U.S. and the travel preference for work trips in those areas. While travel preference is not necessarily an indication of the usage of a given mode, it is an indication of why the estimated ridership for the new or proposed mass transportation is so low, and the impact of these systems on diverting motorists to public transit is minimal. [10,28]

The Unified Transportation Assistance Program (UTAP) and the Urban Mass Transportation Administration (UMTA) are designated as the prime sources of federal funds for both highway and transportation projects, approximately $2.2 billion per year proposed at the beginning of 1974. The current drive to control inflation will probably result in a stretchout or deferral in the outlay of these funds. The available funds will be subjected to a number of competitive needs: operating subsidies for

Table 3-15

1970 Mass Transportation Usage Patterns

Area	Pop. ($x10^6$)	Riders ($x10^3$)	Buses	Trolleys	Subway & El.Cars	R.R. Cars	Travel Preference, %		
							Auto	Rail	Bus
New York	16.3	9,000	8,200	30	7,300	2,400	50.6	26.7	12.3
Chicago	6.7	1,600	3,100		1,100	850	66.3	9.3	15.1
Philadelphia	4.0	1,000	1,850	550	575	400	66.2	8.6	16.0
San Francisco	2.9	850	1,600	400	250	100	74.7	0.7	15.3
Los Angeles	8.3	550	1,900				88.8	0.1	4.7
Boston	2.6	430	1,200	400	350	125	67.4	8.1	12.0
Washington, D.C.	2.5	400	1,800				73.2	0.2	17.4
Baltimore	1.6	350	800				74.5	0.2	16.7
Cleveland	1.9	330	800	55	120		79.0	0.8	13.3
Atlanta	1.2	200	600				84.2	0	10.4

existing systems, escalation costs of construction underway, highways, and the planning, procurement and construction of new transit systems. Therefore, in terms of new systems, additional capacity will be available in the forms of buses, well within the mid-1980 period. The construction lead time and anticipated delays in starting new rail networks make it unlikely that these systems will have any diverting influence on projected usage. In the interim, the purchasing of new automobiles will continue to fulfill basic transportation needs.

3.1.5 An Integrated Forecast of Future Automobile Usage

In the preceding sections, the underlying factors that will determine the probable mid-80's traffic environment were discussed. This section combines these factors with vehicle data to yield forecasts of vehicle utilization by vehicle mix. Average annual mileage figures are projected, and forecasts made of vehicle populations by type, characteristic, and occupancy for various trip purposes.

Vehicle Mileage. The average annual miles driven per passenger car have increased slowly but steadily as shown in Figure 3-16. This trend had been expected to continue because of increased demand by: (1) the increased affluence associated with an older population and subsequent increases in leisure and recreational activities, and (2) the continued, though slower, migration to the suburbs. However, more recent events will have a damping effect on this demand. Constraints imposed by higher fuel costs and possible incentives to those sharing vehicles and using public transportation will somewhat offset the impetus caused by other elements of demand. It is reasonable to expect that per-vehicle travel averages will remain in the vicinity of 10,000 miles annually through 1985.

Figures 3-17 and 3-18 depict the relationship between passenger car registrations and passenger car mileage.

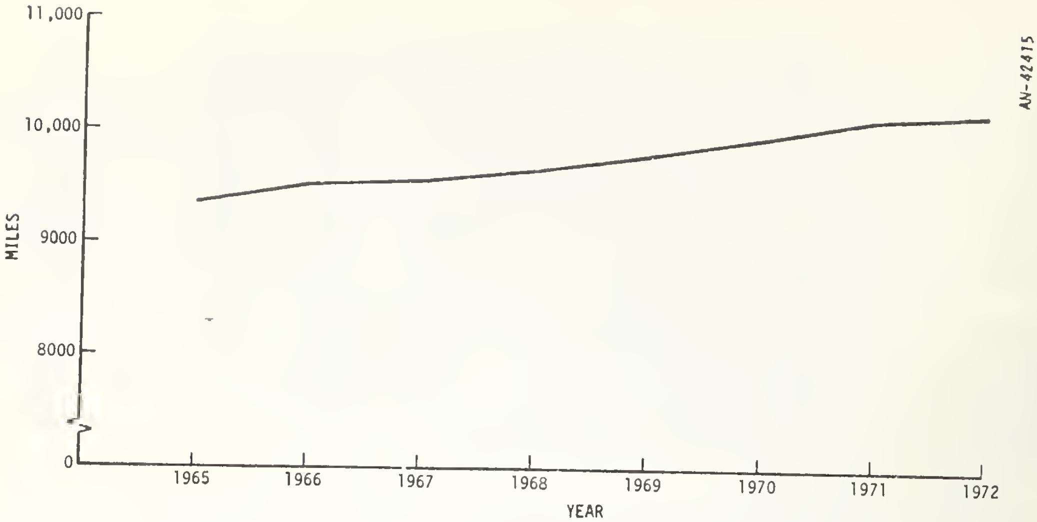


Figure 3-16 Average Annual Mileage, Passenger Cars

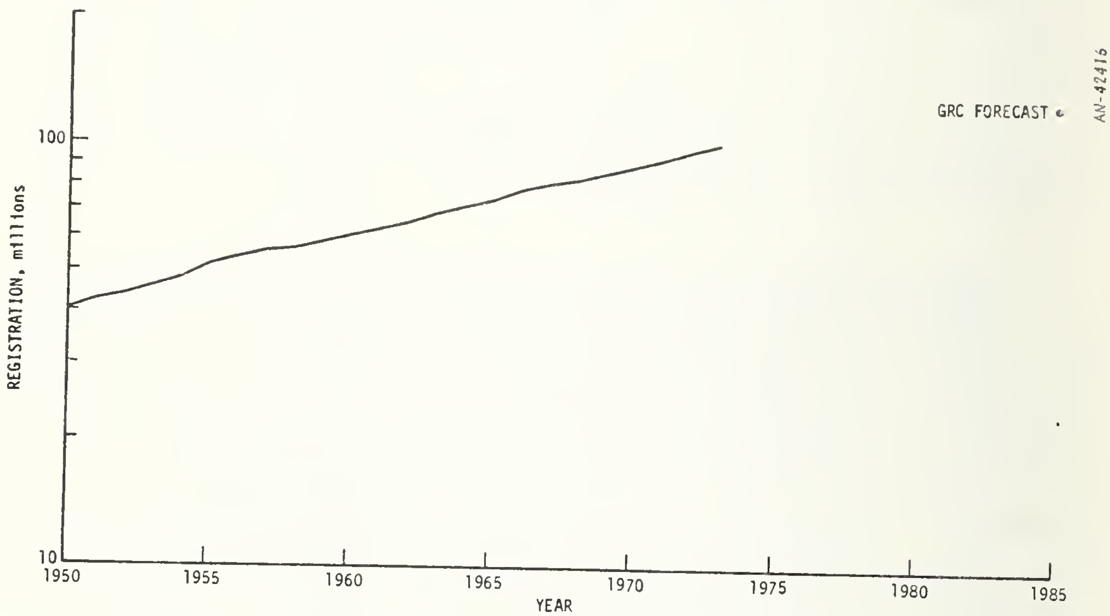


Figure 3-17 Passenger Car Registration, 1950-1973

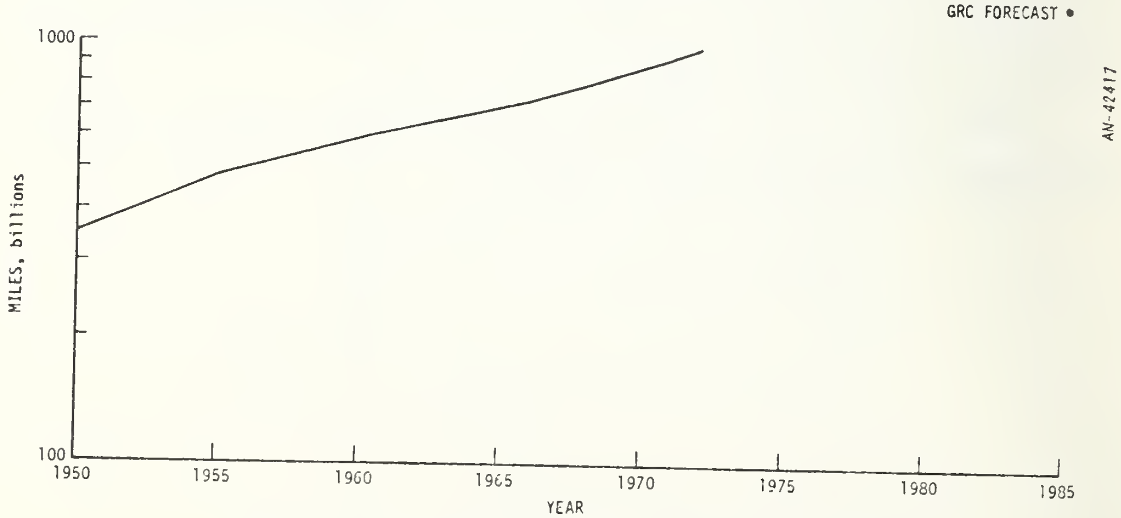


Figure 3-18 Total Passenger Car Miles, 1950-1973

Driver Mileage. The National Personal Transportation Study contains information as to the estimated average annual miles driven per licensed driver classified by age and sex groups. This information is the most comprehensive and up-to-date available. It might be expected that these averages, especially among female drivers, would increase sharply because the low birth rate would allow many more wives to join the work force. However, this work trip demand is expected to be offset by decreases in child-oriented (school, medical, social, etc.) trips. Because of offsetting constraints and demands, it is felt that these averages will remain relatively stable and can be projected to 1985 with reasonable accuracy (see Table 3-16).

The averages were then applied to the estimated driver distribution in 1985 (Table 3-4) to project the 1985 driver mileage and exposure by age and sex groupings as shown in Table 3-17. The predicted personal automobile travel demand mileages reached through this method are consistent with the projections contained in the 1972 National Transportation Report. The [14] DOT reports projections based upon annual growth rates for personal auto travel of 3.8% per annum from 1970 to 1980, and 2.9% per annum from 1980 to 1985 indicate a demand for 1260.8 billion passenger-auto-miles in 1985.

Projected Number of Personal Vehicles. Section 3.1.2, Household Characteristics, projected the number of households by size and age of household head. This information was integrated with car ownership and other economic data to project the cars-per-household ratio shown in Figure 3-7. Application of this ratio (1.4+) to the projected number of households (88 million) indicates a demand for approximately 125 million personal vehicles in 1985 (a figure which also results from using projected total driver mileage and dividing by projected average vehicle mileage).

Table 3-16

Average Annual Passenger Vehicle Miles Driven by Age and Sex Groupings [29]

Age	Drivers	
	Male	Female
16-19	5,461	3,586
20-24	11,425	5,322
25-29	13,931	5,539
30-34	14,496	5,752
35-39	13,035	6,232
40-44	13,133	5,950
45-54	12,582	5,863
55-64	10,603	5,365
65 and over	6,108	3,678
Average Per Driver	8,543	

Table 3-17

Projected 1985 Passenger Vehicle Miles by Age and Sex Groupings

(Millions)

Age	Male Drivers	Female Drivers	Total
16-19	29,184	15,309	44,493
20-24	111,257	44,385	155,642
25-29	141,455	50,089	191,544
30-34	135,668	48,409	184,077
35-39	107,252	47,432	154,684
40-44	84,196	35,367	119,563
45-54	127,053	56,179	183,232
55-64	96,360	48,092	144,452
65 and over	45,676	33,146	78,822
Total	878,101	378,408	1,256,509

Other Vehicles. In this study, the emphasis has been largely on automobiles, however, attention must also be given to other vehicles which are part of this overall traffic environment. Some of these are possible substitutes for automobiles in fulfilling personal transportation needs.

- Trucks and Buses

A comprehensive 1985 forecast of the number of trucks and buses (by type or weight) that will share the nation's highways would require a significant effort beyond the resources available for this study. The approach taken was to base projections on an analysis of past trends and a review of industry and government forecasts. Table 3-18 shows historical data regarding the mix of vehicles using the nation's highways. From the data underlying Figure 3-19, the proportion of trucks has remained relatively constant with a 1973 car-to-truck ratio of (81.3% ÷ 18.7% =) 4.35. Application of this ratio to the 1985 passenger car population forecast of 123.1 million results in an estimated 28.3 million trucks and buses, which compares favorably with the FHWA's Statistics Division's 1985 projection of 28.1 million trucks and buses.

It is expected that the number of buses used for public transit purposes will increase considerably over prior growth rates, especially in urban areas. However, their exposure in the overall traffic environment will be lessened by the increased use of special lanes and routes to provide more effective mass transit.

As noted in Table 3-18, approximately 95% of trucks are of the single-unit type. From recent trends in new truck registrations, shown in Table 3-19, some 61% of these are in the light truck classification (under 6,000 pounds, mainly pickups and vans).

Table 3-18

Vehicle Mix, 1965-1973 (7)

(In Thousands)

Year	Cars	Motorcycles	Buses			Trucks		Total Vehicles
			Commercial	School	Total	Single Unit	Total	
1965	75,252	1,382	85	229.3	314.3	14,008	14,795	91,743
1966	78,353	1,753	84.5	238.7	323.2	14,694	15,517	95,946
1967	80,414	1,953	90	247.9	337.9	15,363	16,193	98,898
1968	83,693	2,100	89.6	262.2	351.8	16,124	16,995	103,140
1969	86,861	2,295	90.3	274.0	364.3	16,942	17,871	107,391
1970	89,280	2,815	90.3	288.7	379.0	17,788	18,748	111,222
1971	92,799	3,345	90.3	307.3	397.6	18,828	19,802	116,344
1972	96,860	3,798	88.8	318.2	407.0	20,249	21,239	122,304
1973	101,237							124,500*

*Excludes motorcycles; trucks and buses estimated at 23,263,000.

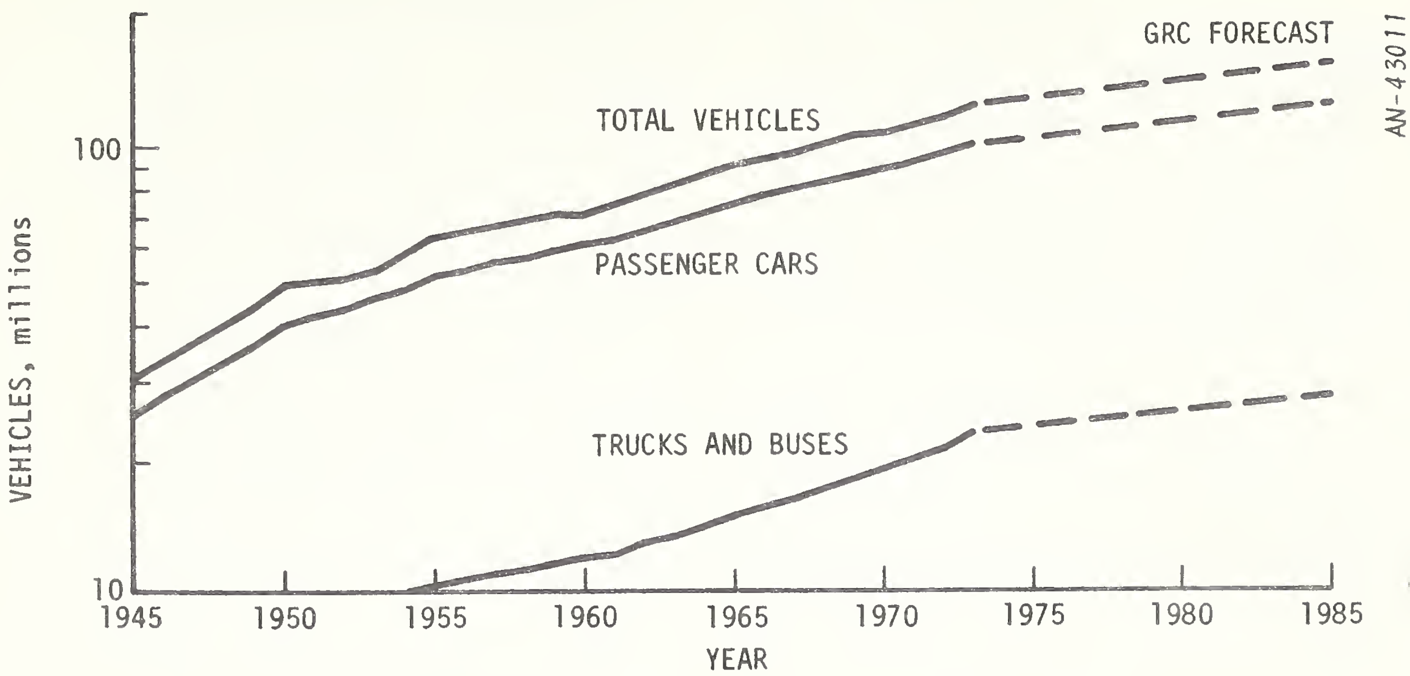


Figure 3-19 Number of Vehicle on the Nations Highways
(Motorcycles excepted)

Table 3-19. New Truck Registrations

Year	Total	Under 6,000 lbs	Percent Under 6,000 Pounds
1970	1,790,177	1,048,566	58.5%
1971	1,981,294	1,209,713	61.1%
1972	2,513,952	1,532,102	60,9%
1973	3,029,074	1,842,891	60.8%

Industry sources state that approximately 65% of the light trucks sold are used for personal and recreational activities, 20% exclusively for business, and 15% for both business and pleasure. Therefore, it can be estimated that about 40% of the nation's truck fleet is satisfying personal transportation demands. However, because of the tendency to equip the larger percentages of these vehicles primarily for recreational purposes, it is estimated that only approximately 2.5 million should be considered as substitutes for automobiles in fulfilling the mid-80's day-to-day travel demand.

Also of significance is the growing popularity of the under-3,000 pound import (and captive import) trucks that are included in the light truck classification (Courier, LUV, Datsun, Mazda). These vehicles are largely used for personal transportation, and can be considered substitutes for automobiles within that weight classification. In 1972, these small trucks composed approximately 10% of the total import market.

Average annual vehicle miles for trucks and buses is given in Table 3-20. In view of the fact that combination truck and interstate buses travel many more miles annually, the relatively low figures shown reflect the great preponderance of light trucks and school buses. The projected average is 12,500 annual miles for the 28.3 million trucks and buses for a total of 354 billion miles annually.

Table 3-20. Average Annual Truck and Bus Mileage [7]

Year	Trucks	Buses
1965	11,587	15,012
1966	11,207	15,012
1967	11,268	14,122
1968	11,571	14,484
1969	11,565	13,826
1970	11,450	13,306
1971	11,465	12,819
1972	12,229	12,553

- Publicly-Owned Automobiles

Approximately 500,000 of the passenger cars presently using the nation's highways are owned by public agencies, mostly federal, state, and local governments. This figure was extended to 1985 and added to the number of automobiles forecast for personal transportation use in order to determine the portion of the total vehicle mix attributable to automobiles.

- Motorcycles

Figure 3-20 indicates the steadily increasing number of motorcycle registrations from 1965 to 1973. There is very little available information pertaining to motorcycle usage. Moreover, recent changes in registration requirements preclude identifying those vehicles used solely for off-road recreational purposes.

An industry source indicates that approximately 75% of the motorcycles sold are puchased by 18 to 24 year old males. If this trend persists, the market will soon become saturated, especially in view of the decline of 18 to 24 year olds in the mid-80's shown in Figure 3-21. Accordingly, a continuance of present growth is forecast until saturation is reached at 8.5 million motorcycles in 1982 and that level is maintained thereafter.

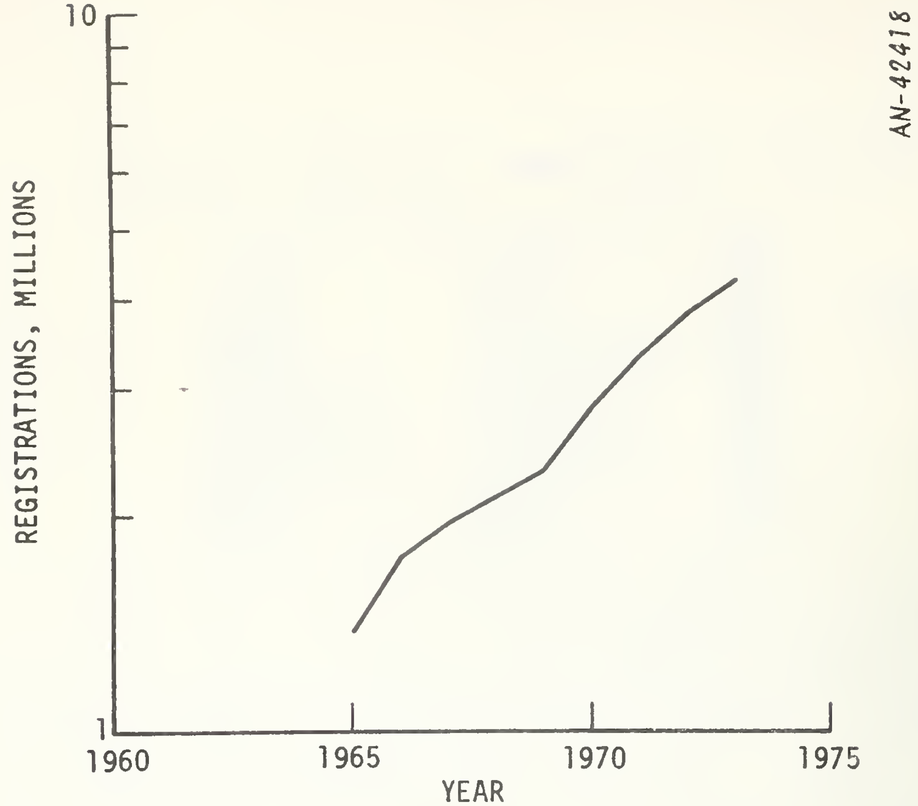


Figure 3-20 Motorcycle Registrations

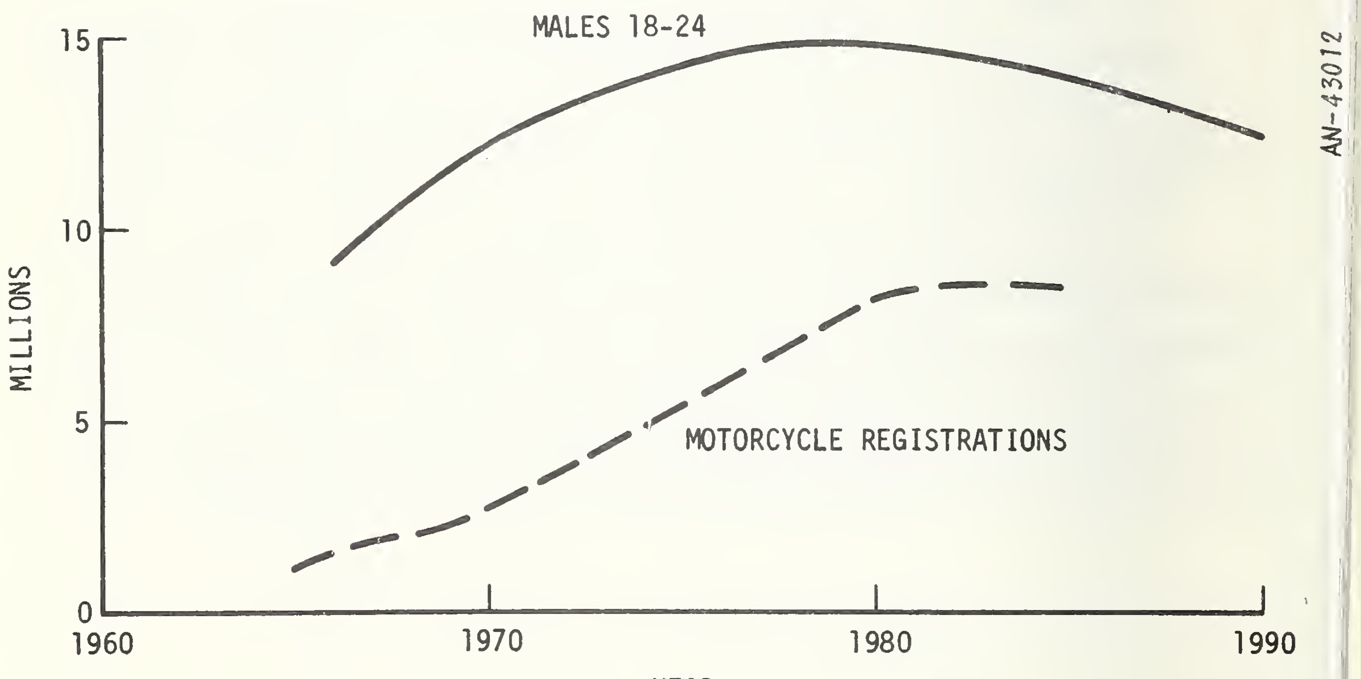


Figure 3-21 U.S. Males 18-24 Years of Age and Motorcycle Registrations

Projected Market Shares of Personal Automobiles by Weight. Figure 3-22 presents the historical and projected market shares for large and small cars using general industry classifications.

Unfortunately, the weight characteristics used in these classifications do not permit a unique assignment of automobiles into categories of under or over 3000 pounds, e.g., a 6-cylinder Ford Maverick weighs 2852 pounds, an 8-cylinder Maverick weighs 3025 pounds, and a presumably compact Oldsmobile Omega weighs 3525 pounds, etc.

Figure 3-22 also shows the market share of cars under 3000 pounds from 1970 to 1973. The percentage of these vehicles dropped considerably in 1972 even though the market share of small cars increased. This was due to weight increases, particularly in the Plymouth Valiant, which caused changes in category. It is expected that the addition of safety equipment and environmental controls on future models will cause further increases in weight and that more domestic models currently in the 2800 to 3000 pound categories will move into the over-3000 pound category. For example, 1974 specifications indicate the following curb weights for four high volume models:

AMC Gremlin, V-8	2990 pounds
AMC Javelin 6	2929 pounds
Ford Mustang II	2923 pounds
Ford Maverick, 4-door	2964 pounds

Unless there is a weight reduction elsewhere, the planned installation of catalytic converters for emission control and no-damage bumpers on 1975 models will place these vehicles in the over-3000 pound category.

At the present time, imports constitute about 15% of the U.S. car market. Domestic car makers have stated that they can "live with" a ratio in that vicinity so this percentage has been used in the 1985 projections. Approximately 97% of the imports are in the under-3000 pound category; accordingly, this percentage was also used in the projections.

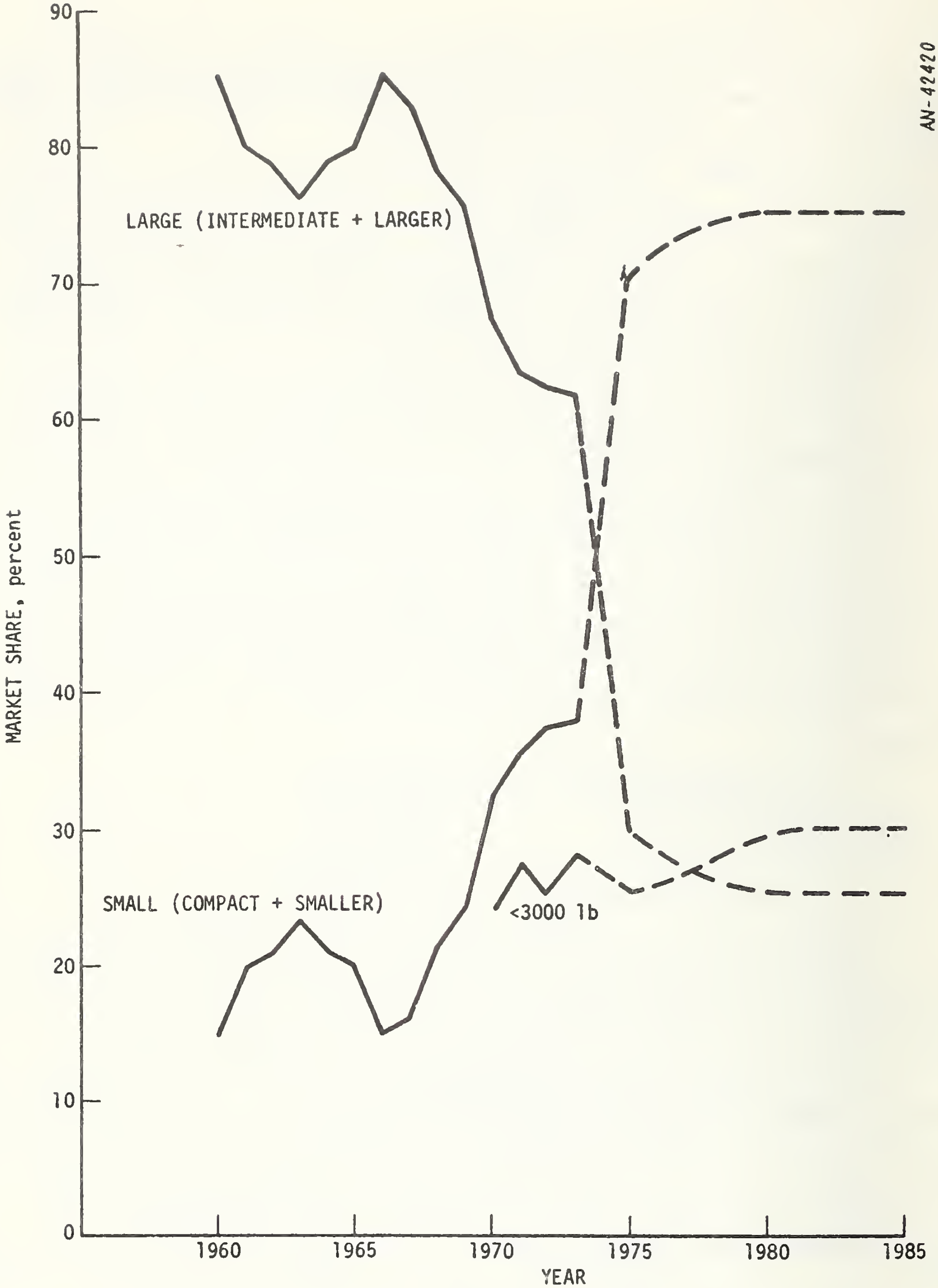


Figure 3-22 Historical and Projected Auto Sales, 1960–1985

Industry media have been examined to determine recent trends and the future outlook for individual automobile weights and operating life. First-quarter 1974 data indicate that small cars (compact and smaller) accounted for approximately 50% of the market. Industry sources have projected that this share will increase to between 55 to 65 percent of the market within the next few years, and other production experts predict that 55% of all domestic 1975 models will be compacts or smaller.

Considering past and present trends and industry outlooks, it is envisioned that the market share of small cars will rise sharply to 70% in 1975 (55% domestic, 15% import) with a more modest rate of increase to a saturation level of 75% in 1980. Cars in the under-3000 pound category, however, are predicted to retain a market share of approximately 30% because of the weight increases described previously.

Projected Age Profile of Automobiles. New car sales can be translated to total car population by properly accounting for the expected life of each year's automobiles. These age profiles are also useful in assessing the time required for new cars with safety features to be in wide use. Analysis of historical data regarding cars in use by year of manufacture reveals that attempts to isolate the share of cars by each model year is uncertain because of yearly variations in production shown in Figure 3-23. However, by aggregating these cars into blocks of three years, the yearly variations are "smoothed", and trends can be discerned. After examining the age structure of cars in use from 1955 to the present (it was felt that lack of production during WW II years would distort earlier data), an extrapolation of past and present trends indicates the following car-age profile:

Age of Car	Percentage
Under 3 years	30.2
3-5 years	31.0
6-8 years	23.0
Over 8 years	15.8

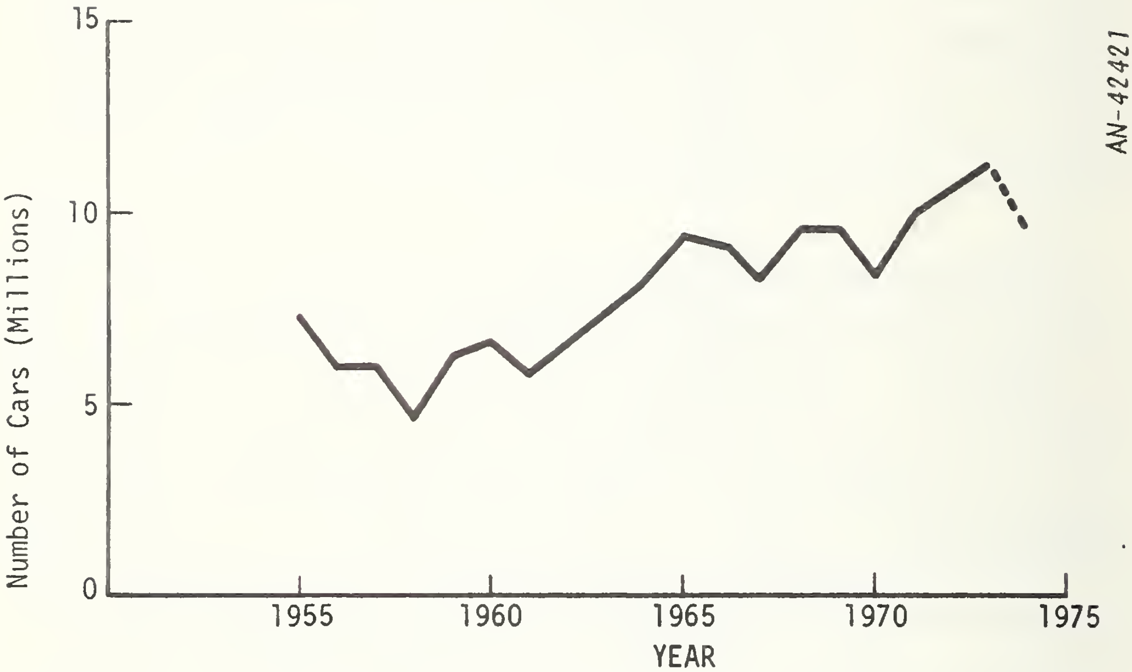


Figure 3-23 New Car Registrations, 1955-1975

The 1985 car-age profile will differ slightly from past and present trends because of two considerations:

- The shifts in the age structure of the population will result in decreased numbers of car owners in the younger groups (traditionally owners of older cars) and larger increases in the age groups that can afford newer vehicles.
- The decrease in survivability in terms of car durability associated with smaller and lighter cars.

Therefore, the projected car-age profile for 1985 is expected to be:

Age of Car	Percentage
Under 3 years	33
3-5 years	34
6-8 years	21
Over 8 years	12

Urban-Rural Division of Vehicle Usage. Section 3.1.4 treated characteristics of the present urban and rural highway systems, planned changes to those systems, and possible effects of alternative modes of transportation. Because of the variation in types and severity of accidents occurring in urban and rural highway environments, an analysis was made of historical data regarding the proportions of travel occurring in those environments. Table 3-21 indicates historical mileages and proportions for automobiles and trucks/buses in each environment and the projections to 1985.

The rationale underlying the projected total mileage for automobiles and for trucks and buses has been discussed previously. Forecasts of urban/rural proportions were made after considering observable trends since 1950 (see Figures 3-24 and 3-25), planned improvements to the urban system (as discussed in Section 3.1.3), and Federal Highway Administration Projections.

Table 3-21

Historical and Projected Urban and Rural Mileages; Automobiles, Trucks and Buses

(Millions of Miles)

	Automobiles					Trucks and Buses					Total Vehicles				
	Rural	%	Urban	%	Total	Rural	%	Urban	%	Total	Rural	%	Urban	%	Total
1965	333,412	46.8	378,182	53.2	711,594	105,360	59.8	70,850	40.2	176,210	438,772	49.4	449,032	50.6	887,812
1966	351,372	46.7	400,368	53.3	751,740	109,348	61.2	69,409	38.8	178,210	460,772	49.5	469,777	50.5	930,497
1967	359,228	46.4	414,975	53.6	774,203	116,832	62.4	70,518	37.6	187,350	476,060	49.5	485,493	50.5	961,553
1968	375,338	46.1	438,692	53.9	814,030	127,022	63.0	74,597	37.0	201,619	502,360	49.5	513,289	50.5	1,015,649
1969	392,843	45.7	466,015	54.3	858,858	133,185	62.9	78,532	37.1	211,717	526,028	49.1	544,547	50.9	1,070,575
1970	406,449	45.1	494,543	54.9	900,992	136,883	62.3	82,830	37.7	219,713	543,332	48.5	577,373	51.5	1,120,705
1971	428,943	44.9	525,212	55.1	954,155	144,371	61.6	89,959	38.4	234,330	573,314	48.3	615,171	51.7	1,186,289
1972	435,957	43.4	567,541	56.1	1,003,498	154,270	58.2	110,574	41.8	264,884	590,227	46.5	678,115	53.5	1,268,342
1985	467,000	37.8	769,000	62.2	1,236,000	202,000	57.1	152,000	42.9	354,000	669,000	42.1	921,000	57.9	1,590,000

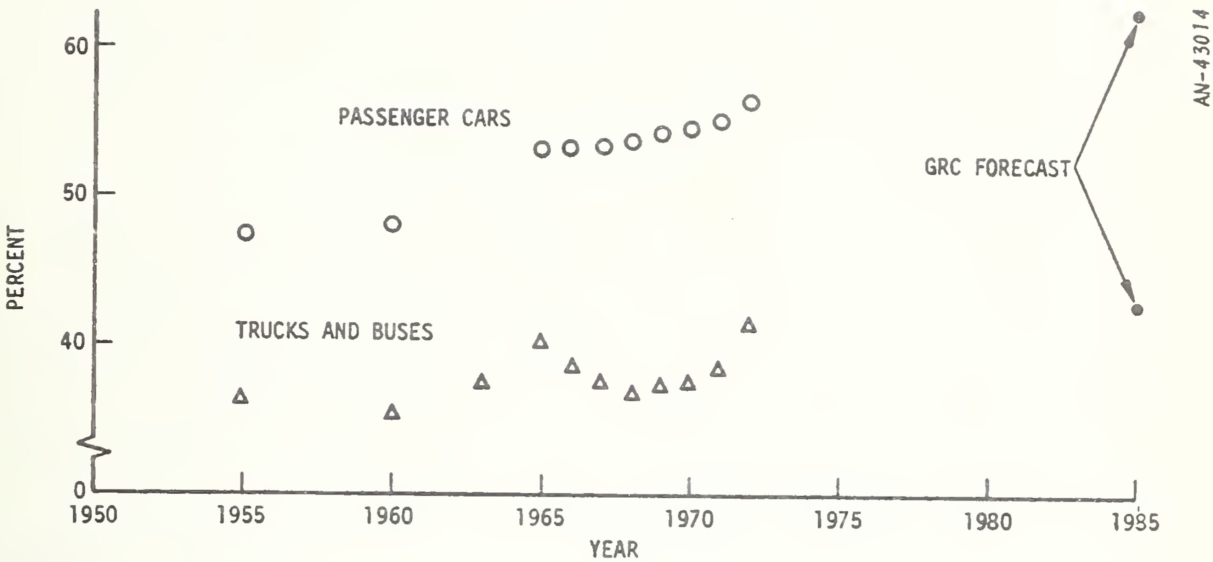


Figure 3-24 Urban Mileage as a Proportion of Total Vehicle Mileage

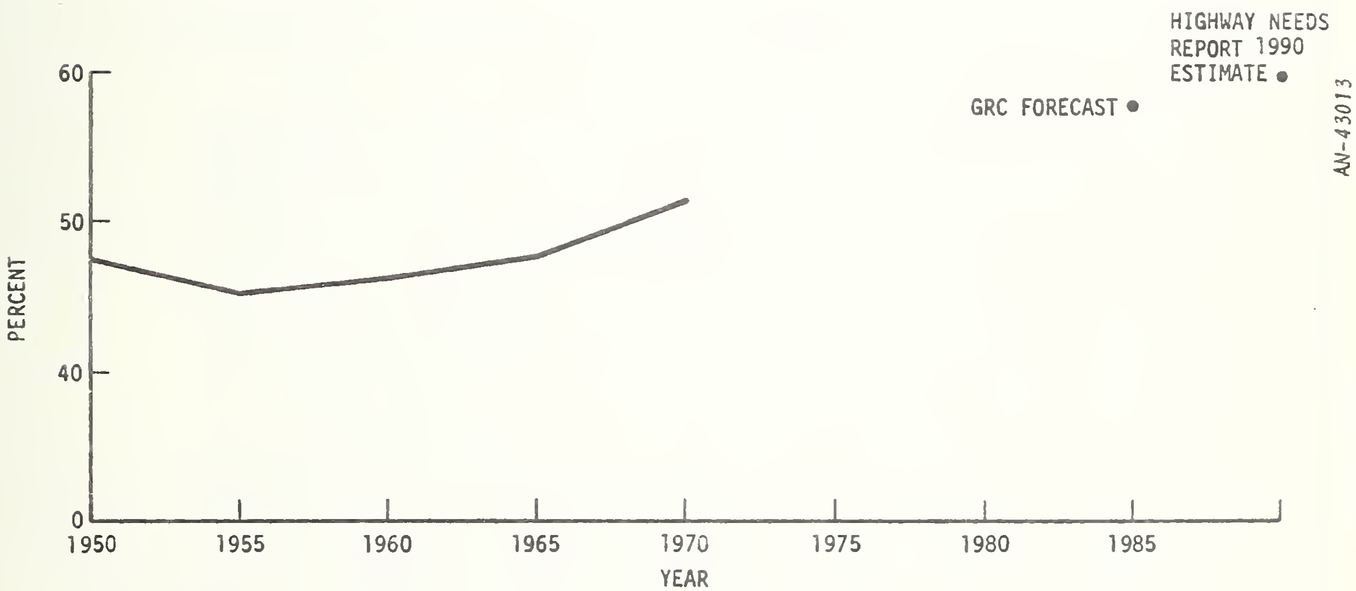


Figure 3-25 Urban Mileage as a Proportion of Total Mileage; Passenger Cars, Trucks and Buses

Automobile Occupancy and Trip Purpose. One additional consideration for passenger cars operating in the mid-80's environment is the use they will be subjected to. Historical trends, presented in Tables 3-22 and 3-23, indicate passenger car usage in terms of trip purpose, trip length, occupancy, and their respective distributions. Corresponding data segregated according to vehicle weight or size classification is unavailable.

The original FHWA source of the tabulated data presents additional statistical details on occupancy; however, it does not discuss user motivations for car usage or the reasons for the shifts in usage occurring between the two surveys. Certain inferences can be drawn from the data exhibiting the larger changes: (1) the greater use of the car for non-business or work-related trips reflects the increased affluence of the car-owning population, (2) the increase in length of the work-related trips reflects the increased movement to suburban residence, and (3) the decrease in vacation trip length reflects a diversion to air travel for long distances.

The findings of the survey of 1969-70 car usage were summarized as follows:

- Average occupancy for all trip purposes combined was 1.9 per trip.
- Average occupancy varied from a high of 3.3 per trip for vacations to a low of 1.4 per trip for "to and from work" trips with the average occupancy generally increasing with increasing trip length.
- One-occupant trips represent 50.2% of all trips.
- Approximately 74% of "to and from work" trips were in one-occupant cars.

In the projection of recent trends, two key factors bear on future automobile occupancy: (1) the projected decreases in household size, and (2) the greater proportion of non-work trips. These suggest that for non-work trips, there will be small decreases in occupancy accompanied by somewhat longer trip lengths.

Table 3-22

CAR USAGE TRENDS
MAJOR PURPOSE OF TRAVEL

PURPOSE	1951-58 (1)				1969-70 (2)				Δ			
	Trips	Travel	Trip* (1-way)	Occupants*	Trips	Travel	Trip* (1-way)	Occupants*	Trips	Travel	Trip	Occupants*
1. Earning Living												
To and from work	33.6%	26.8%	6.4	1.3	32.3%	34.1%	9.4	1.4	-1.3%	+7.3%	+3.0	+0.1
Business related	12.2	16.8	10.2	1.3	4.4	8.0	16.0	1.6	-7.8	-8.8	+5.8	+0.3
Total	45.8%	43.6%	7.4	1.3	36.7%	42.1%	10.2	1.4	-9.1%	-1.5%		
2. Family Business												
Medical and dental	1.6%	1.9%	9.7	2.0	1.8%	1.6%	8.3	2.1	+0.2%	-0.3%	-1.4	+0.1
Shopping	15.8	7.2	3.8	1.9	15.4	7.6	4.4	2.0	-0.4	+0.4	+0.6	+0.1
Other	12.1	9.9	6.8	1.8	14.2	10.4	6.5	1.9	+2.1	+0.5	+0.3	+0.1
Total	29.5%	19.0%	5.4	1.9	31.4%	19.6%	5.5	2.0	+1.9%	+0.6%		
3. Educational, Civic or Religious	7.6%	3.7%	4.1	2.4	9.4%	5.0%	4.7	2.5	+1.8%	+1.3%	+0.6	+0.1
4. Social & Recreational												
Vacations	0.1%	4.9%	296.0	2.7	0.1%	2.5%	165.1	3.3	0	-2.4%	-130.9	+0.6
Visits					9.0	12.2	12.0	2.3				
Pleasure rides	7.2	12.7	14.2	2.5	1.4	3.1	19.6	2.7				
Other	9.8	16.1	12.3	2.4	12.0	15.5	11.4	2.6				
Total	17.1%	33.7%	14.8	2.4	22.5%	33.3%	13.1	2.5	+5.4%	+0.4%		
5. All Purposes	100.0%	100.0%			100.0%	100.0%	8.9	1.9				

SOURCE DATA: (1) Automobile Facts and Figures 1968; (2) Automobile Facts and Figures 1972.

*Average Miles or Occupants

Table 3-23

CAR USAGE TRENDS

DISTRIBUTION OF TRIPS AND VEHICLE-MILES OF TRAVEL

Trip Length (One-way Miles)	1951-56 (1)		1969-70 (2)		Δ	
	Trips	Miles	Trips	Miles	Trips	Miles
Under 5	59.6%	13.2%	54.1%	11.1%	-5.5%	-2.1%
5 - 9	19.9	15.4	19.6	13.8	-0.3	-1.6
10 - 15	8.1	11.2	13.8	18.7	+5.7	+7.5
16 - 20	4.2	8.2	4.3	9.1	+0.1	+0.9
21 - 30	3.7	10.4	4.0	11.8	+0.3	+1.4
31 - 40	1.6	6.5	1.6	6.6	0	+0.1
41 - 50	0.8	4.3	0.8	4.3	0	0
51 - 99	1.3	10.8	1.0	7.6	-0.3	-3.2
100 and over	0.8	20.0	0.8	17.0	0	-3.0
	100%	100%	100%	100%		

SOURCE DATA:

(1) Automobile Facts and Figures 1968

(2) Automobile Facts and Figures 1972

Also to be considered is the effect of increasing fuel costs on occupancy and travel for all purposes. With approximately 88% of all trips not exceeding 15 miles one-way, it is unlikely that even doubling or tripling gasoline prices would significantly impact the trips made within this range. Fuel costs represent a relatively small percentage of car expenses in comparison to insurance and depreciation. Undoubtedly, increased fuel prices will curtail work-related travel for the lower income car-owning groups and those who have access to an acceptable form of public transportation and some curtailment of the discretionary social and recreational trips. Some higher occupancy can be anticipated in work trips through car-pooling. On balance, however, there is no basis to project any significant net change from these varied influences upon 1985 usage.

Summary of Projected 1985 Automobile Usage. This section presents a summary of the projected traffic environment that the RSV will operate in in the mid-80's. The description of the environment are provided in quantitative terms where possible; qualitative descriptions or assessments are presented for those areas that don't lend themselves to numerical descriptions or projections.

- Vehicle Population and Mix

The projected total vehicle population in the U.S. is 160,400,000, and is composed of the following vehicle types:

Automobiles:	123,100,000	privately-owned
	500,000	publicly-owned
	123,600,000	total
Trucks and buses:	28,300,000	
Motorcycles:	8,500,000	

- Automobile Characteristics

The age distribution of all automobiles is estimated to be as follows:

Vehicle Age (Years)	Percent	Number of Automobiles
Under 3	33	40,790,000
3-5	34	42,020,000
6-8	21	25,960,000
Over 8	12	14,830,000
	100	123,600,000

The age distribution of the total automobile population by two basic size classifications, intermediate and larger, and compact and smaller, is estimated to be the following:

Intermediate and Larger

Vehicle Age (Years)	Percent	Number of Automobiles
Under 3	25	10,200,000
3-5	25	10,510,000
6-8	27.5	7,140,000
Over 8	47	6,970,000
		34,820,000

Compact and Smaller

Vehicle Age (Years)	Percent	Number of Automobiles
Under 3	75	30,590,000
3-5	75	31,510,000
6-8	72.5	18,820,000
Over 8	53	7,860,000
		88,780,000

Within the compact and smaller classes are those automobiles whose weight does not exceed 3000 pounds. The estimated number of vehicles in this sub-class and their age distribution as a percentage of the age groupings for all automobiles is as follows:

Vehicle Age (Years)	Percent	Number of Automobiles
Under 3	30	12,240,000
3-5	30	12,610,000
6-8	28	7,270,000
Over 8	27	4,000,000
		36,120,000

- Driving Population

The total driving population (ages 16 and over) in the U.S. in 1985 is estimated at 147.1 million out of a total potential driving population of 175.7 million. The male driving population is estimated to be 90% of the total males 16 years of age and over as contrasted to 87% in 1970. For females, the percentage increase is more marked, 78% in 1985 as opposed to 61% in 1970. The breakdown of projected male and female drivers by age groups follows.

	Driver Population (in millions)			% of Drivers	
Age	Male	Female	Total	Male	Female
16-19	5.3	4.3	9.6	75	62
20-24	9.7	8.3	18.1	94.5	83
25-29	10.1	9.0	19.2	95	86
30-34	9.4	8.4	17.8	95	86
35-39	8.2	7.6	15.8	95	87
40-44	6.4	5.9	12.4	95	85
45-54	10.1	9.6	19.7	95	84
55-64	9.1	9.0	18.1	92	78
65 and over	7.5	9.0	16.5	72	58
Totals	75.9	71.2	147.1	90	78

- Driving Patterns

The average annual miles driven per automobile will remain in the vicinity of 10,000 miles. However, in order to accommodate the greater number of vehicles on the road and continuing urbanization, the FHWA plans call for an increase in urban highway linear mileage of approximately 66% by the end of the 1980 decade, anticipating nearly twice as much vehicle miles travel on the urban system as in 1970. Rural highway mileage and vehicle miles traveled on them will experience relatively small increases in comparison.

There was no indication of any shifts in day/night or wet/dry driving patterns.

- Alternative Transportation Modes

New or proposed mass transportation systems in major metropolitan areas are anticipated to have a minimal influence in diverting travel from the automobile to a public transit system. The highest diversion estimate was 5% for the proposed Los Angeles system.

No evidence was found of any serious considerations being given to the use of dual-mode automobile systems. The greatest departure from the conventional bus-train networks was the proposed personal rapid transit concept being considered for Denver. This approach, similar to that being demonstrated in the Morgantown project, has yet to evidence its effectiveness as a viable alternative to the automobile or even the efficient Denver bus system. Similarly, there was no indication of any seriously proposed legislation barring vehicles (except in limited shopping mall areas in certain downtown areas) or restricting vehicle size or characteristics in local or regional areas.

- Occupancy and Travel

The travel purposes, mileage per trip purpose, and related occupancy trends are projected to be essentially the same as those reported by the 1969-1970 FHWA surveys. Influencing factors that might tend to increase certain usages and trip miles (primarily for non-work related areas) were considered to be offset by increasing fuel costs. Similarly, where decreased household size trends might result in decreased occupancy, ride-sharing trends would offset that decrease.

3.2 ACCIDENT PROJECTIONS

3.2.1 Introduction

The purpose of Section 3.2 is to provide a definitive quantitative description of all major accident events. With such a data base, societal costs are estimated for the projected environment; priorities are established in terms of maximum safety payoffs; and a specific set of values based on a demonstrated need can be assigned to each related specification.

Unfortunately, there is a lack of statistically valid data, representative of nationwide experience, to describe recent accident histories in the scope and detail deemed desirable for the accident projections. Therefore, in those instances where the only available data is known to be biased, to constitute an inadequate sample, or to be otherwise suspect, the study was confronted with two disagreeable choices: (1) to by-pass the accident event; or (2) to address the event, recognizing the inadequacies of the basic sources and data. The latter alternative was selected; projections were made as necessary with the appropriate qualifications so that some insight could be had into the events of interest. Further, if more adequate data becomes available in the future, any questionable event(s) could be reassessed and modified as indicated.

This section of the report presents the methodology and data used in assessing recent and current accident patterns and in projecting these patterns into the 1985 time frame. The result of this effort is to provide a set of baseline projections. Influence factors, such as existing and potential legislation, safety programs, and others are considered in Section 3.4.1 in order to determine their effects on the baseline projections. Societal costs are established (see Section 3.3.1) for the accident events that the RSV would encounter in order to define those that have the maximum payoff potentials.

Section 3.3.2 discusses the accident events considered, the descriptive variables in each accident event for which data was sought, and the agencies and data banks which are sources for accident data.

Past and current accident data are assessed and projections for 1985 are presented in Section 3.2.3.

Section 3.2.4 contains the summarized data in terms of projected number of accidents, fatalities, and injuries for each accident category. In addition, the accident distributions are presented for each accident category by automobile weight class, relative impact speed and impact direction.

3.2.2 Accident Patterns

Current accident assessment and accident projections are the most vital parts of the program definition phase. Ideally, one output of this study area should provide a comprehensive statistical data base which would:

1. Permit a definitive quantitative description of each accident event of interest, such descriptions to be representative of national experience.
2. Permit a realistic evaluation of advances in the man and environment systems that would influence the vehicle system in terms of accident involvements and their consequences.

Such a data base would enable the development of a set of performance specifications related to demonstrated needs as well as the development of the projections of the accident environment required to characterize the RSV.

<u>Accident Descriptions</u>. Accidents involving passenger cars were categorized into the following six classes, listed in a decreasing order of importance relative to the fatalities currently associated with each class:

1. Vehicle with other vehicles
2. Non-collisions
3. Vehicle with pedestrians
4. Collisions with fixed objects
5. Vehicle with motorcycles
6. Vehicle with pedalcycles

These categories or classifications are essentially the same as those used by the National Safety Council (NSC) and by state and county agencies when compiling and reporting accident statistics. Unfortunately, in many instances while compiling and reporting accidents, motorcycles were classified as "motor vehicles". As a result, the term vehicle pertains to automobiles and motorcycles. Therefore, motorcycle accident statistics are included in the above accident categories. When the car-with-motorcycle category is evaluated, the motorcycle data is segregated (insofar as possible in view of the limited data) from overall motor vehicle accidents.

Two other accident categories, used by the NSC: collision with railroad trains, and "other collisions", were not considered in this study. The difference in mass between passenger cars and trains is such that vehicle countermeasures are inappropriate; the logical countermeasure in this accident case is in the grade crossing area. The "other" category, usually entails collisions with animals, and is comparatively infrequent. The countermeasures which may be applied to the RSV to cope with the vehicle to vehicle and other accident classes considered should provide benefits to the "other" case.

For each accident class, descriptors of the accident in terms of variables of interest were identified by means of a tree format. The common variables in each case were the geographical location (urban, rural), the time of day or lighting conditions (day, night), and the road condition (wet, dry). Below these levels of variables, unique variables for each accident class were identified. A summary of the accident descriptions considered follows.

- Vehicle With Other Vehicles

The accident descriptions for this class are shown in Figure 3-26. The unique variables in this class are the car area impacted, the car weights, and the impact speed. At the terminal point of each branch, the desired accident data included, as a minimum, the total number of accidents (N), fatalities (F), injuries (I), and property damage (D).

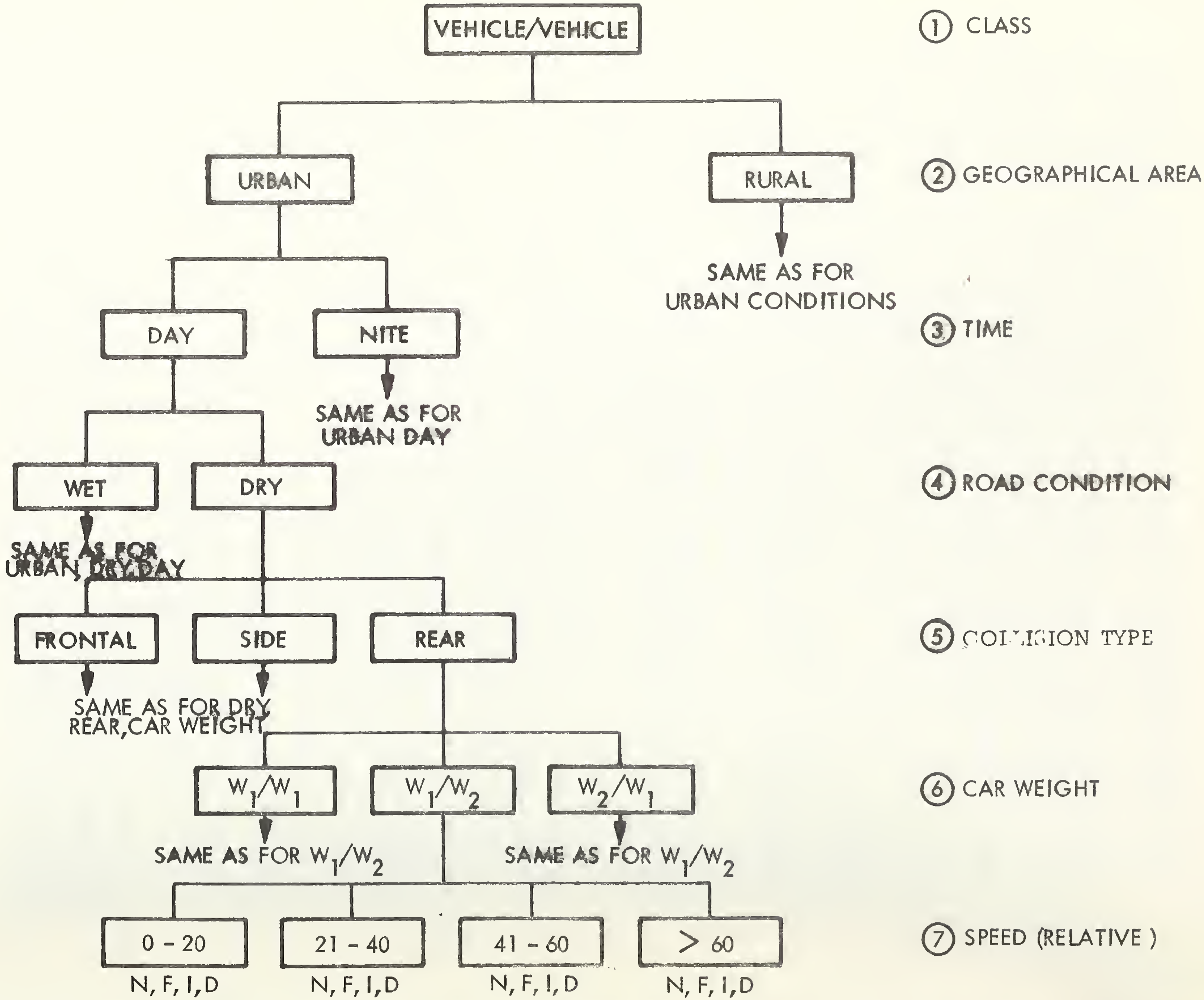


Figure 3-26. Car and Other Vehicle Accident Variables

Two weight ranges were considered, small cars under 3000 pounds (W_1) and large cars and vehicles over 3000 pounds (W_2). Three types of vehicle to vehicle collisions, frontal, side, and rear, were selected with each collision type involving different pairings of the small car and the large vehicle. Detailed data on collisions involving pairs of large vehicles were not required. The final variable was the relative speed at impact specified in one of four speed ranges.

- Non-Collision

The description of the non-collision case and its component variables is shown in Figure 3-27. The unique variables of interest are the car weight, road geometry, and speed. The non-collision event of prime interest is overturning involving the small car on straight and on curved roads and at each of two speed groupings.

- Vehicle With Pedestrian

The unique variables in the car impacts with pedestrians, shown in Figure 3-28, are the car area impacting the pedestrian, car weight, speed at impact, and the pedestrian age. Three impact areas are considered; prime interest is in frontal impacts with side and rear impacts of lesser interest. For the frontal impact, two car weight ranges are considered; prime interest is centered on the small car in accidents occurring in each of three speed at impact groupings. For each speed at impact group, three pedestrian age groups, approximating three different body sizes, comprised the final variable.

- Vehicle With Fixed Objects

Figure 3-29 shows the unique variables for this class, the struck object, its geometry, the car weight, the impacting area of the car, and the speed at impact. The object of interest is rigid; the geometries of interest are the cylindricals (trees, poles, hydrants,

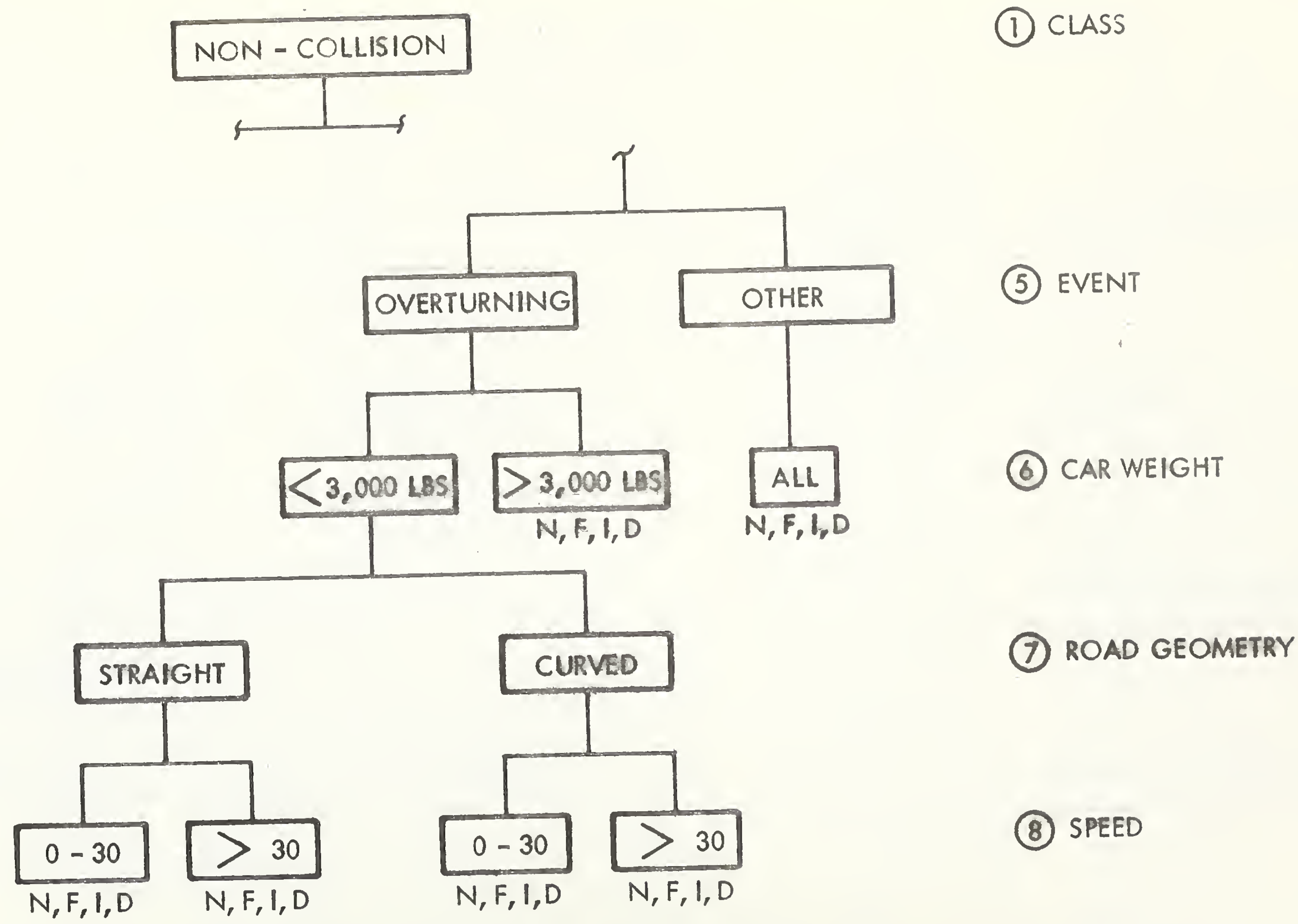


Figure 3-27 Non-Collision Accident Variables

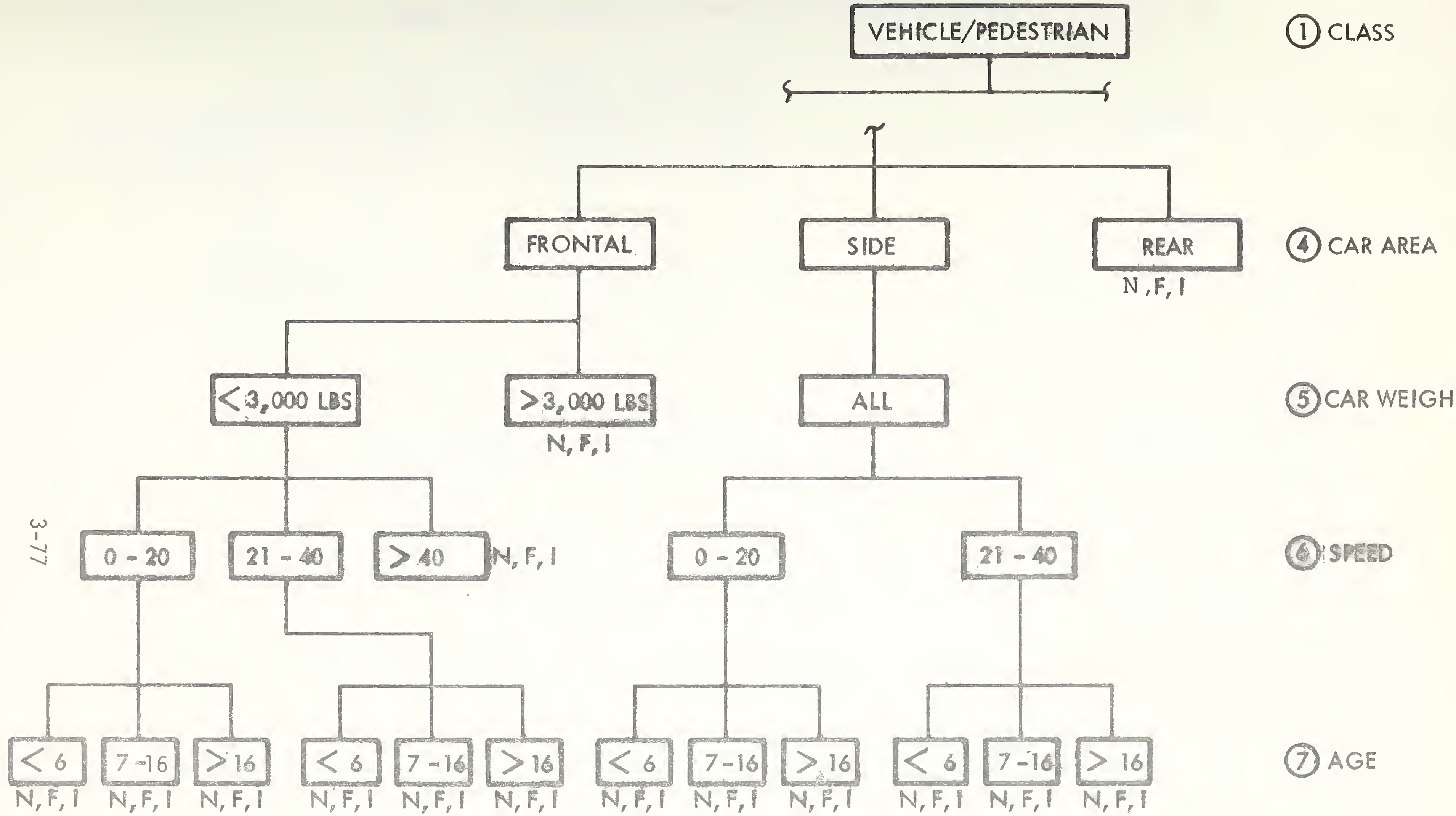


Figure 3-28. Vehicle with Pedestrian Accident Variables

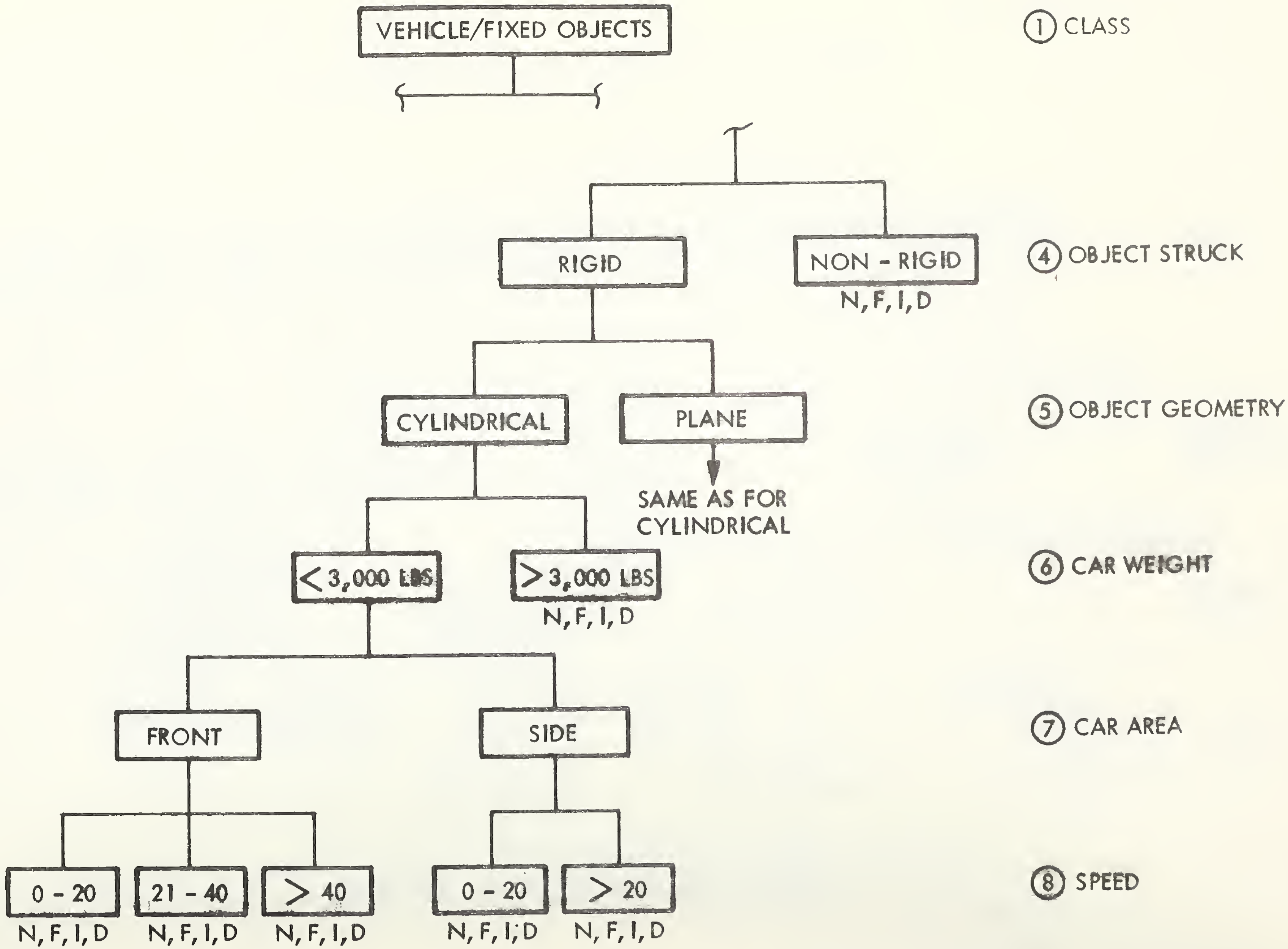


Figure 3-29. Vehicle with Fixed Object Accident Variables

etc.) and the planes (abutments, walls, barriers, etc.). The car of prime interest is the small one involved in frontal and side impacts with the identified rigid objects at each of three impact speed groupings.

- Vehicle With Motorcycles

Three unique variables, shown in Figure 3-30, are considered in the car with motorcycle collisions. The impact area includes the car front impacting the motorcycle, the motorcycle impacting the car side, and the motorcycle striking the car rear. The car of prime interest is the small car involved in frontal and side impacts in each of three speed at impact groupings.

- Vehicle With Pedalcycles

The unique variables in this class, shown in Figure 3-31, are essentially the same as those for the car with motorcycle class except that the accident where the bicycle strikes the rear of the car was not considered.

- Causal Data

In addition to the described variables, additional descriptive data of causal factors attributed to the vehicle in each accident class was desired. The factors of interest are primarily those associated with accident avoidance and functional systems and which, because of inadequate design or performance, are primary or contributing causes of accidents. Typical systems of interest are the driver's sight line and visual aids, lighting and signaling, vehicle stability in braking while turning or in running off the road, etc. Unfortunately, such data is not reported in mass accident statistics, and where such data is available, it is the subject of special studies. Therefore, no attempt was made to formalize such causal data needs, but rather to conduct literature searches for specific systems as part of the characterization and specification development tasks.

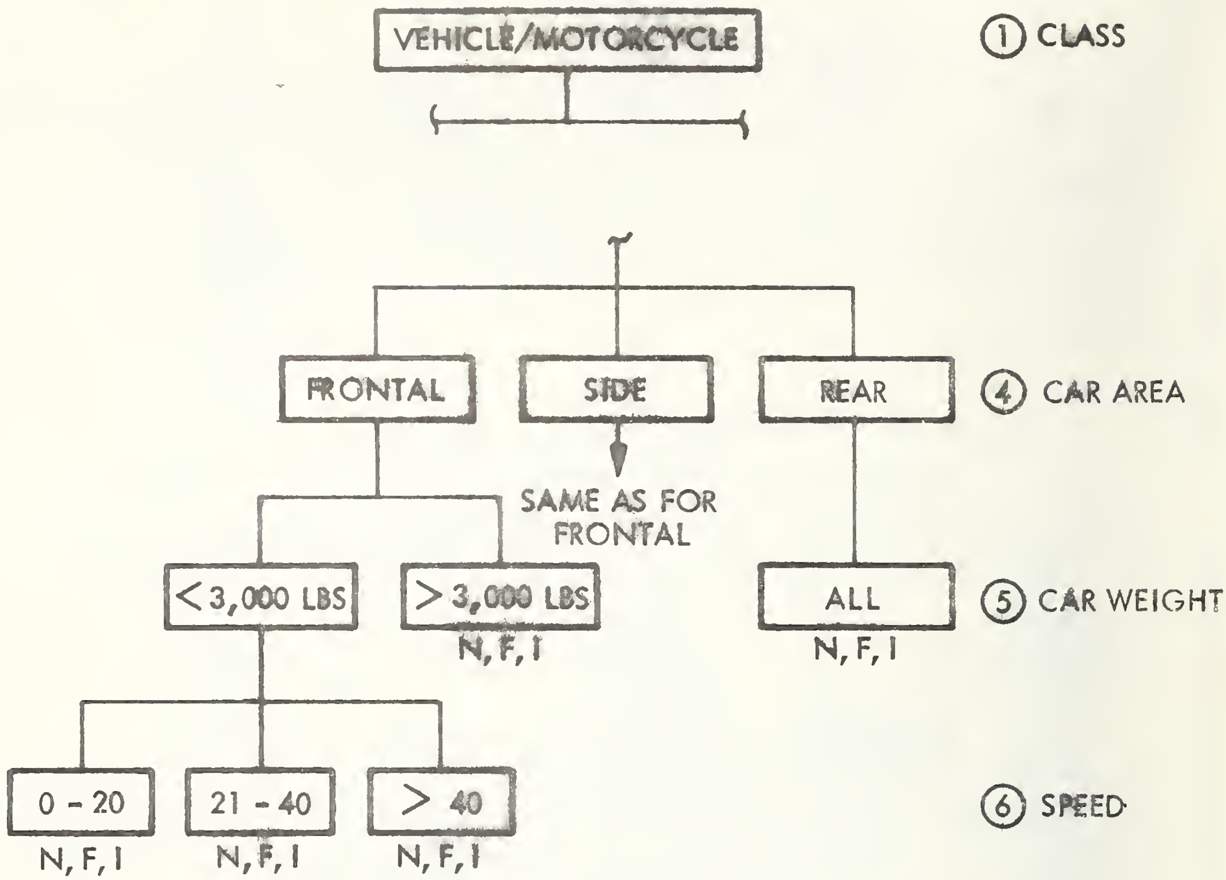


Figure 3-30. Vehicle with Motorcycle Accident Variables

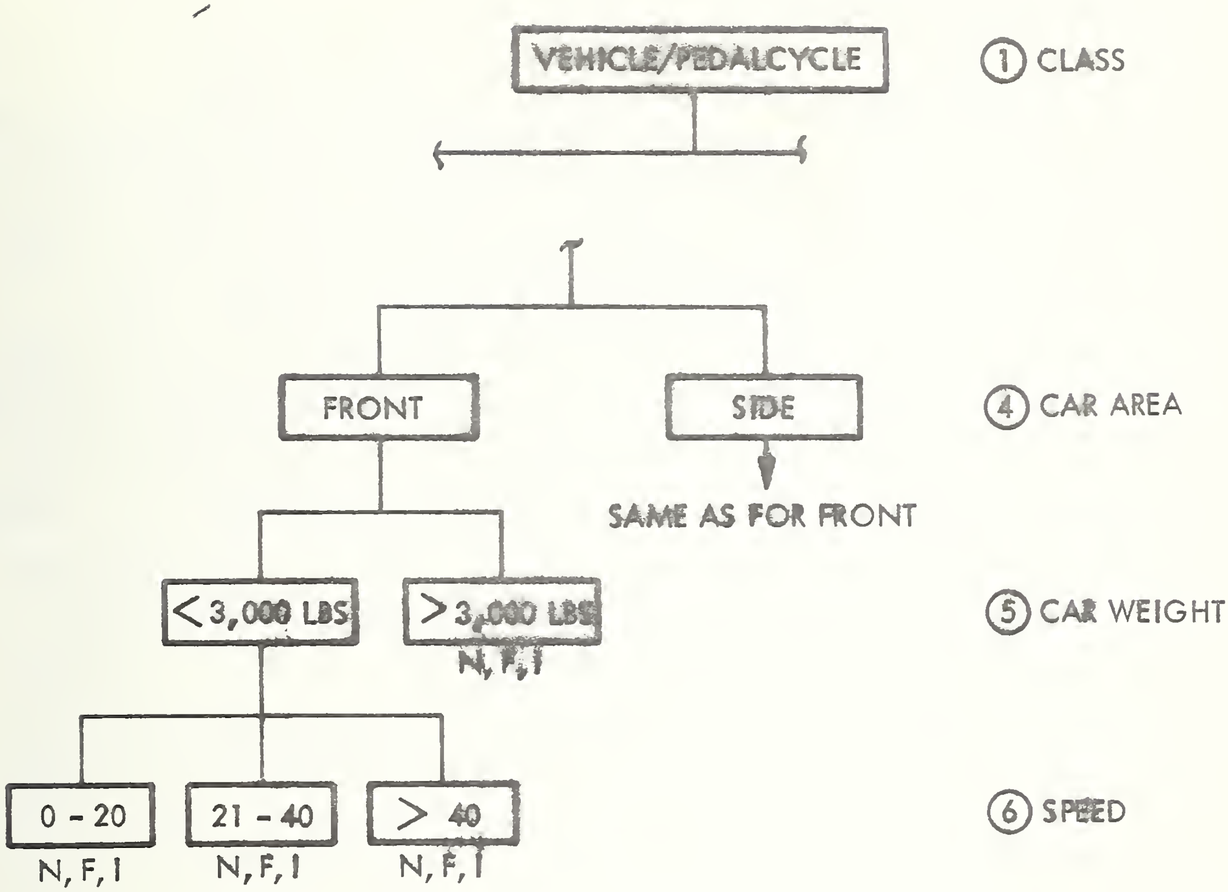


Figure 3-31. Vehicle with Pedalcycle Accident Variables

The description of the data sources and the contents of the available statistical data from each source used to describe the current accident environment follows.

Accident Data. Ideally, a study of nationwide accidents would draw upon a single authoritative source for comprehensive, detailed, and consistently defined accident information. In fact, no such single source exists. There are several sources of nationwide data, but these do not provide the detail required for the RSV program. Therefore, sources which do provide more detailed information about motor vehicle accidents, but are necessarily less extensive in their geographic coverage, were also examined. These additional sources include the various regional (state and county) programs in which detailed accident descriptions are collected and tabulated. These programs are sufficiently broad in their coverage of the different accident types. A second similar source is the data compiled at regional and local levels for particular types of accidents or particular degrees of accident severity.

In summary, accident data are available in three broad categories, or levels of detail:

1. Nationwide data with summary descriptions of overall accident characteristics.
2. Regional data with a full scope of accident types and fairly detailed descriptions of each major class of accident.
3. Regional or local data which provides still greater detail for a more narrowly-defined set of accident types.

These various limitations in scope and detail of available accident data pose a number of problems in trying to set forth a comprehensive

assessment of vehicle accidents; most notably, the question of using regional data to infer nationwide accident characteristics.

- Nationwide Data Sources (Level I)

There are several sources which compile nationwide data. For many years, the National Safety Council (NSC) has been publishing national statistics in their annual report, Accident Facts. The NSC data is widely accepted and used, although it is not universally endorsed as a valid representation of the nation's vehicle safety problems. Inquiries to NSC representatives indicated that no additional information, beyond that contained in Accident Facts, is available. Following a review of other nationwide data sources, the NSC information was selected to represent overall national accident conditions.

The federal government also compiles accident information. The Department of Transportation's National Highway Traffic Safety Administration (NHTSA) collects data from various state and local government agencies as well as from private organizations. NHTSA's National Accident Summary (NAS) and Fatality Analysis File (FAF) are based upon extensive data from many, but not all, states, thus their total numbers cannot be used directly to indicate overall national statistics. But proportionate distributions of accident characteristics from these two files can be used, and were so employed in this study.

Nationwide accident data are also compiled and published by several insurance organizations, notably the Travelers Insurance Company and the Insurance Information Institute. The Travelers Insurance Company publishes data, which are reproduced in part in the Statistical Abstract and other government sources. The Insurance Information Institute compiles data which are also published in the Statistical Abstract and some limited use was made of this data.

Noting that there have been a number of extensive data collection and reporting programs within individual states, the suitability of these

sources as representative samples of nationwide traffic and accident conditions was examined. If characteristics of the population and traffic environment in some states are similar to national descriptors, then the reported accident statistics might reasonably be assumed to represent a national sample. This possibility was explored by using techniques of mathematical statistics (factor analysis); however, this approach was unproductive.

- State and Regional Data Sources (Level 2)

There are a number of states which publish periodic, detailed reports of traffic accidents, California, North Carolina and New York being the most extensive, the characteristics of each of these states is sufficiently distinctive to require great care in using the reported data (many of these distinctive characteristics are noted in Section 3.2.3). These data sources were used to rationalize selected details within aggregate national accident categories and in making comparisons with other information. Oregon, Washington and other state data were also used for selected detail.

There are a number of specialized institutions which compile state and regional accident data. Calspan (New York), the University of North Carolina's Highway Safety Research Center (HSRC), and the University of Michigan's Highway Safety Research Institute (HSRI), compile accident statistics and carry out extensive related research activities. Data from these sources is generally more useful than the state publications because it provides greater detail, and is typically computerized so that data classifications can be tailored to meet the needs of the user. HSRI has been maintaining data files from a number of regions throughout the country, including two counties in Michigan and one (each) in Texas, Colorado, Washington, and Florida. This study used the HSRI accident data from Oakland County, Michigan; this choice was predicated on the availability of specific detail desired for the RSV study, and the comparative ease with which it could be obtained.

- Oakland County Data

After a review with members of the HSRI staff on the suitability of the various accident data banks available for establishing the current accident environment and subsequently projecting these conditions to the mid-1980's, it was decided to use the data available for Oakland County, Michigan, for the calendar years 1970 to 1973.

The Oakland County file contains: (1) information on each unit involved in an accident (that is, car to: other motor vehicle, pedestrian, fixed object, pedalcycle, etc.), (2) general information about location or type of accident (that is, urban-rural, wet-dry, day-night, etc.), and (3) information on fatalities, injuries, and property damage in the accidents. Speed at impact is not part of the file. The more comprehensive in-depth evaluations provided by MDAI teams in the CPIR files were used to include this variable.

The Oakland County data set is only exactly representative of a medium-sized midwestern semi-rural county, but it does yield a good distribution of different type accidents which occur in a variety of different roadways. Projections to national data from Oakland County take into account the data base size plus its geographical nature.

The Oakland County data file for the different years contain data on all the reportable motor vehicle traffic accidents that were submitted to the Michigan State Police on the UD-10 accident report form. The state police and all local police agencies in Michigan are required to complete and submit a UD-10 form for each reportable accident investigated by them or reported to them. In Michigan, reportable accidents are those that result in either injuries or in property damage greater than $200.

The data submitted to HSRI contains information for each accident on (1) each traffic unit involved in the accident, (2) general information on the location, conditions, and type of accident, and (3) information about occupants and injuries in the accident.

The data of interest to characterize the current accident conditions relates to the following vehicle-accident configuration and their relationships to the environment. The collisions of interest as far as general categories are concerned are:

Vehicle to other vehicle
Vehicle to fixed objects
Vehicle to pedestrians
Vehicle to pedalcycles
Vehicle to motorcycles
and non-collisions - rollovers.

The variables from the Michigan files used to describe and discern accident patterns relative to possible safety design specifications based on a cost-benefit analysis were:

1. Vehicle weight (less than 3000 lbs and greater than 3000 lbs).
2. Primary impact area (front, side, rear).
3. Road surface (wet-dry).
4. Visibility (day-night).
5. Driving environment (urban-rural).
6. Speed at impact (this value was estimated for the general categories and primary impact areas from MDAI-CPIR 3 file).
7. Age and sex of drivers of vehicles involved in accidents.

The Oakland County Mass Accident Data File was used to provide Bivariate Frequency tables of accidents and accident conditions. The following scheme was used to reduce data on all motor vehicle accidents to data pertinent for the development of the design specification of the RSV.

1. Variable describing all motor vehicles was globally filtered so that of all motor vehicle accidents in the file, only those accidents where at least one vehicle was a passenger car would be included in the analysis.

2. Motor vehicle accident types were then broken down into five collision categories of interest where passenger cars were involved in collisions with:

(1) Other moving motor vehicles
(2) Parked cars
(3) Parked cars and fixed objects
(4) Rollovers and non-collisions
(5) Pedestrians
(6) Pedalcycles

3. The five collision categories by themselves provide the frequency distribution of these accident types relative to all motor vehicle accidents. Further, the accident tables indicate the distribution of fatalities, injuries, and property damage by accident type and consequently, as a percentage of all motor vehicle accidents. The very close relation (correlation) between these distributions of accidents and frequencies and those provided by "Accident Facts" at the total accident levels indicate that further analysis of the Oakland County data would be representative of the nationwide accident picture.

4. Each of the six accident collision categories with its associated accident (fatalities, injuries, property damage) was then analyzed to determine frequencies and severities associated with variables which are descriptive of an accident.

- Multidisciplinary Accident Investigation (MDAI) Data (Level 3)

This data stems from an in-depth investigation of an accident by a number of highly trained accident investigation teams. These teams are sponsored by the National Highway Traffic Safety Administration, the MVMA and Canadian Department of Transportation. The information generated by these teams is recorded on the General Motors' Collision Performance and Injury Report (Revision 3) which lists over 800 different variables (descriptive items).

The Level 3 data are referred to as the MDAI data, or, collectively, as the MDAI files. Three working files are created where variables concern the vehicle, occupant, and the injury. MDAI data provide a highly detailed review of a large number of accidents (currently about 5,000 vehicle cases). Many of the vehicle case variables can be categorized into the following groups:

- Case Identification (date, time, etc.)
- Environment (weather, road alignment, etc.)
- Vehicle Malfunctions (brakes, tires, electrical, etc.)
- Collision Description (vehicle to vehicle, vehicle to object, impact speed, collision area, etc.)
- Case Vehicle (description, damage, etc.)
- Driver (impairment, education, record, etc.)
- Program Matrix cells (team recommendations)
- Occupant Summary (injury severity by position, etc.)

These detailed investigations are one source of data in the analysis of traffic accidents and must be compared with mass police data in order to infer the frequency distribution of certain classes of accident events. In effect, a synthesis of the levels permits a search for relationships or patterns which is impossible or unrealistically biased if the levels are used apart from each other.

It is recognized that MDAI files do not contain a cross section of typical accidents. The files are biased toward the more severe accidents since one of the criteria for case selection is that at least one vehicle must be towed from the accident scene. The in-depth data were prepared to cover the circumstances, causes, and effects of the collisions studied from the point of view of several disciplines. The one drawback of this file for national data statistics is its size and the emphasis put on investigation of fatal or severe accidents. Thus, the extrapolation of fatalities from this source would significantly overstate the national numbers. The file

does contain a wide variety of accident types from many geographical regions which are reported accurately by professionals at a level of detail not available elsewhere. Specifically, the reported ratio of the number of accidents that resulted only in property damage to the number of accidents resulting in death or injury in the MDAI files is 0.25:1 in contrast to the nationwide ratio of 11:1. [30]

In this study, the CPIR data file was used in a limited way. The file was used to determine the impact speeds of struck and striking cars for front, side and rear end collisions in both the urban and rural traffic environment. The intent was to provide a measure of severity (fatalities, injuries, and property damage) for impact speed ranges. The CPIR file was the only source available which reliably reports impact speeds.

3.2.3 Accident Assessment and Projections

The discussion in Section 3.2.2 noted that accident data are available in three broadly-defined categories, each of which is limited in scope or in the level of desired detail. The central consideration in the use of these data is to draw upon them in such a way that they are reasonably representative of the national condition which is being portrayed. For example, data from a rural state in the southeast or an urban county in the midwest cannot be used with any confidence to infer the overall national pattern of vehicle collisions in relation to single-car accidents or pedestrian accidents. The driving populations and traffic environments in these regions are too non-representative to be used as a reflection of aggregate national conditions. And yet, data from particular regions can be used with some confidence in a more limited portrayal of, say, collisions with fixed objects in an urban area. If other, nationwide, data is used to establish the number of urban, fixed object collisions in relation to other accident types, then, that regional data can be used to provide the additional detail of the given accident type (e.g., type of impacted object, point of impact, speed, etc.) required to meet the needs of program definition and development of specifications.

Thus, the overall framework, or structure, within which the various data sources will be used is as follows:

- Nationwide data is used to establish the number and distribution of accidents within broad categories of accident types, traffic environment and driver characteristics. To the extent practicable, these data are also used to establish the recent time trends of accident patterns.
- The more detailed data from regional sources are used to establish greater definition within the individual accident categories. The regional sources provide percentage distributions for further disaggregation of the nationwide data. For example, from nationwide data, the number of fatal accidents involving two-vehicle collisions in rural areas can be identified. Regional data are then used to identify the percentage distribution of point of impact, given that there has been a fatal two-car, rural collision. Another still more detailed "level" of regional data is employed for some additional accident detail.

In short, the analysis of accident data is carried out by integrating three levels of data. While the "population" from which the data for the three levels are taken is successively less representative of national conditions, the data are used with successively less assumptions. The result is a detailed description which is a representative best estimate of nationwide accident patterns.

It should be noted that the integration of different data sources poses several problems in itself. Most of these stem from differences in definitions and ground rules associated with data collection. As discussed in succeeding sections, there are differences in the definition of injury and property damage. The data have been adjusted to ensure consistency (i.e., injuries include disabling and non-disabling injuries; property

damage is based on a threshold of $200). The choice of what to include in these categories was dictated by the need to conform to the definitions used in the regional studies. In each instance, national data were revised to conform with the more detailed regional statistics.

The general methods used to forecast accidents warrant comment. In the course of this study, the applicability of various forecasting procedures were considered, and other studies of accident determinants and future accident conditions were reviewed. Needless to say, there are a multitude of factors involving vehicles, drivers and passengers, and the traffic environment which influence the number and character or automobile accidents. The task of identifying cause-and-effect is greatly complicated by the fact that so many of these factors are interrelated and so many are inadequately documented. Driver age, driving habits, and type of automobile are closely interrelated, but simplified statistical correlations of any one of these characteristics with accident rates leads to specious inferences of cause-and-effect. On the other hand, the close interrelationship among explanatory variables can simplify the task of forecasting. If the interrelationships continue to prevail, then an account of variations in one parameter can capture much of the influence of others.

The possibility of direct mathematical projections of historical accident statistics was explored, including a review of the studies by the National Bureau of Standards which examine various mathematical forecasting procedures. Aggregate time-series projections, including various "smoothing" techniques, presume an underlying consistency into the future of population- and transportation-related factors. In the usage projection section of this report, it was indicated that this presumption would not be valid. Moreover, there are several current and pending influence factors which bear directly upon accidents and represent direct deviations from historical precedents. The recently legislated reduction in speed limits coupled with higher gasoline prices seems to have affected accident rates. The pending implementation of new motor vehicle safety features will also have an impact upon future

accidents, as will proposed programs to control drunk-driving and to remove or shield dangerous roadside objects. Other examples are noted in subsequent paragraphs.

The procedures used in this study are a compromise between mathematical projections and subjective estimates. From reviews of accident studies, driver age emerges as the strongest single influence on accident rates. Thus a central element of the forecasting procedure for most accident types is a separate accounting of accidents for each age group (Section 3.1 indicated the significant shifts in age structure of the driving population which will take place by 1985). Recent historical data were examined to discern any year-to-year trends in involvement rates, i.e., the ratio of drivers in accidents to total number of drivers. These time trends are taken into account in forecasting to 1985. In developing 1985 projections, adjustments are also made to reflect the anticipated increase of urban driving and of small car usage. In defining the details of day-night and wet-dry occurrences, plus distributions of point of impact, no change from existing proportions was assumed.

In the subsections that follow, forecasts of accidents are developed for the classes of vehicle accidents described in Section 3.2.2.

Within each class, details are provided for fatalities, injuries and property damage (for accidents and victims), further disaggregated by driving conditions (day/night, wet/dry), locale (urban/rural), point of impact and weight class of car. These data are developed and displayed in "trees" showing the various characteristics.

Data are developed for a 1972 baseline, then projections for 1985 are set forth. These baseline forecasts are made exclusive of the effects of a number of influence factors which have potential significant impacts on future accident rates. Among these factors are the various Highway Safety Program Standards established under the Highway Safety Act of 1966. The impact of these standards can only be assessed on the basis of judgment, and thus are treated separately from the baseline projections.

Vehicle With Other Vehicle Accidents. In establishing a basis for forecasting accidents in this as well as other categories, data from various sources were examined including the National Safety Council, NHTSA's Office of Statistics and Analysis, insurance agencies, state agencies and the Highway Safety Research Institute (HSRI). The evaluation and subsequent use of the data from these sources in structuring the current car with other vehicle accident patterns is presented in the following sections. Complete details are provided in the Appendices (A through F).

- Fatal and Injury Accidents, 1972

Level 1 data for fatal accidents, together with the division between rural/urban areas, were taken from NSC information published in Accident Facts. Data for 1972 include 48,800 fatal vehicle accidents (all types) with 18,900 fatal accidents involving two vehicles of which 5,500 accidents occurred in urban areas and 13,400 in rural areas.

The number of injury accidents and injuried persons as reported by NSC is low in comparison with other data sources. For 1972, Accident Facts indicates a total of 1.4 million injury accidents with 2.1 million injuries in all types of motor vehicle accidents. Travelers Insurance Companies report 4.85 million injuries, and the Insurance Information Institute indicates 5.19 million for the same year. This discrepancy is due to differences in the definition of "injury". Accident Facts data include only those "disabling beyond date of accident", which excludes most Category C injuries.

The three categories of injuries as defined in the Manual of Uniform Definitions of Motor Vehicle Accidents are as follows:

A. Bleeding wound, distorted member, or any condition that required victim to be carried from the scene.

B. Other visible injuries, such as bruises, abrasions, swelling, limping, or other painful movement.

C. Complaint of pain, without visible signs of injury; or momentary unconsciousness.

Category C injuries comprise 32.3% of all injuries reported in North Carolina, 41.5% in California, and 66% in New York.

Because the data used for the lower levels of accident description variables does not distinguish between categories of injuries (and does include Category C), a method was provided so that Category C injuries could be added to NSC data. It was determined from other data sources (including National Accident Summary File data which corresponds closely with figures from California and New York state files) that the average injury accident involves 1.5 injured victims. Using the number of injured persons (in all accidents) as reported by the Insurance Information Institute, 5.19 million, and dividing by a factor of 1.5, a 1972 total of 3.46 million injury accidents is obtained.

The total injury accidents were allocated to motor vehicle-vehicle collisions and to urban and rural settings in accordance with the proportions given in NSC data. The resulting figures are:

All Injury Accidents	3,460,000, of which 74.8% are
Two-vehicle accidents	2,588,000 including
Urban (64.9%)	1,680.000
Rural (35.1%)	908.000

The allocation to night and day conditions for fatal accidents was in accordance with NSC proportions. For day-night injury accidents, the percentages were derived from HSRI data.

A comparison of data from various sources on the distribution of fatal and injury accidents under day and night conditions follows:

ACCIDENT SEVERITY BY LIGHTING CONDITIONS

	Day		Night	
Data Source	% Fatal	% Injury	% Fatal	% Injury
NSC	47	--	53	--
North Carolina State	46.4	61.8	53.6	38.2
New York State	41.7	60.8	58.3	39.2
HSRI	42.4	62.7	57.6	37.3

The NSC, North Carolina and New York data aggregate accidents by type. With the HSRI file data, it was possible to isolate vehicle/vehicle collisions occurring in the different light conditions, and therefore, for injury accidents, HSRI day/night distributions were used.

NSC data was used to allocate fatal and injury accidents among dry and wet road surface conditions. This allocation was considered to be representative of the national environment after comparing the several sources shown below.

ACCIDENT SEVERITY BY CONDITION OF ROAD SURFACE

	Fatal		Injury	
Data Source	% Dry	% Wet	% Dry	% Wet
NSC	77.3	22.7	68.2	31.8
New York State	65.6	34.4	56.9	43.1
North Carolina State	80.4	19.6	76.0	24.0
HSRI	72.3	27.7	62.6	37.4

The resulting 1972 distribution of vehicle to vehicle accidents involving fatalities and injuries by the top level variables is summarized below.

1972 SEVERITY DISTRIBUTIONS FOR
VEHICLE-VEHICLE ACCIDENTS

Variable	Fatal	Injury
All conditions	18,900	2,588,000
Area:		
Urban	5,500	1,679,600
Rural	13,400	908,400
Lighting:		
Day	8,900	1,623,000
Night	10,000	965,000
Road Condition:		
Dry	14,600	1,765,000
Wet	4,300	823,000

It should be noted that the source data is generally available only in bivariate form as presented in the preceding table rather than the more desirable multivariate form as described by the tree format discussed in Section 3.2.2.

- Property Damage Accidents, 1972

Property damage accidents as reported by NSC cannot be related to data furnished by other sources because of differences in definitions. NSC's definition of property damage accidents is:

> "Property damage accident is an accident which results in property damage, but in which no person is injured."

State data sources and HSRI data include only those accidents that resulted in property damages greater than $200. In order to use these sources, the national data was adjusted to conform with this more limited definition.

NSC's reported number of property damage accidents for 1972 is approximately 10.75 times the total number of fatal and injury accidents. Examination of sources which use the $200 threshold reveals that a factor approximately equal to 2 appears to prevail (i.e., 2 x [fatal + injury accidents] = property damage accidents).

FATAL & INJURY VS PROPERTY DAMAGE ACCIDENTS

Data Source	Fatal & Injury	Property Damage	Ratio
North Carolina	42,474	85,396	2.01
National Accident Summary File	253,580	523,375	2.06
HSRI	41,797	82,449	1.97

Because the HSRI ratio was derived specifically from two vehicle collision data, this ratio was applied to calculate national property damage accident totals.

The allocation of property damage by urban/rural areas was made in accordance with NSC proportions.

Property damage accidents were also allocated to day/night conditions in accordance with HSRI data, again because this data was considered more definitive for this collision category. Other source data are shown in the following table for comparative purposes.

DISTRIBUTION OF ACCIDENTS BY LIGHTING CONDITIONS

Data Source	% Day	% Night
NSC (all accidents)	68.5	31.5
New York State (all property damage accidents)	63.6	36.4
North Carolina state (all accidents)	65.6	34.4
HSRI (property damage, 2-vehicle accidents)	71.5	28.5

The allocation of property damage to wet/dry conditions was made in accordance with NSC's all-accidents proportions (which coincided well with other sources), viz., ~66% of all accidents occur under dry road conditions.

- Fatalities and Injuries, 1972

The preceding discussion has been concerned with accidents. For purposes of assessing the overall societal consequences of such accidents, the number of fatalities and injuries is of direct interest. NSC data was used to determine the fatal accident/fatality ratio for two-vehicle collisions. Shown below are the statistics for the past four years (data from previous years are not compatible) indicating average number of deaths per fatal accident occurring in urban and rural environments.

NSC TWO-VEHICLE COLLISION, FATAL ACCIDENT DATA

	1969	1970	1971	1972
Total				
Accidents	18,300	18,100	18,100	18,900
Fatalities	24,000	23,300	23,300	24,200
Fatalities/Accident	1.31	1.29	1.29	1.28

NSC TWO-VEHICLE COLLISION, FATAL ACCIDENT DATA (Cont'd)

	1969	1970	1971	1972
Urban				
Accidents	5,400	5,250	5,300	5,500
Fatalities	6,000	5,800	5,700	5,900
Fatalities/Accident	1.11	1.10	1.08	1.07
Rural				
Accidents	12,900	12,850	12,800	13,400
Fatalities	18,000	17,500	17,600	18,300
Fatalities/Accident	1.40	1.36	1.37	1.37

For comparative purposes, data from other sources follow:

OTHER TWO-VEHICLE COLLISION, FATAL ACCIDENT DATA

	New York 1972	California 1972	North Carolina 1972	National Accident Summary 1971
Total				
Accidents	823	1,678	539	12,900
Fatalities	979	2,029	652	16,483
Fatalities/Accident	1.19	1.21	1.21	1.28
Urban		Not Available	Not Available	
Accidents	265			4,349
Fatalities	295			5,103
Fatalities/Accident	1.11			1.17
Rural				
Accidents	558			8,551
Fatalities	684			11,380
Fatalities/Accident	1.23			1.33

NSC data does not delineate those injuries occurring in two vehicle collisions so other available data were examined in order to determine an average for the number of injuries resulting from injury accidents. A comparison of the data from these sources follows:

TWO-VEHICLE COLLISION, INJURY ACCIDENT DATA

	New York 1972	California 1972	North Carolina 1972	National Accident Summary Summary 1971
Total				
Accidents	155,512	105,855	22,857	751,027
Injuries	257,268	168,038	40,035	1,242,033
Injuries/Accident	1.65	1.59	1.75	1.65
Urban				
Accidents	104,129			532,675
Injuries	170,299			854,098
Injuries/Accident	1.63			1.60
Rural				
Accidents	51,320			218,352
Injuries	86,969			387,935
Injuries/Accident	1.69			1.78

The National Accident Summary File data are considered to be most representative of national patterns and their ratios were used for baseline projections.

- Vehicle Weight

The next level of disaggregation of the accident data is the distribution of fatal, injury and property damage accidents by the weight class of vehicle involved in the accidents. Two categories are set forth: vehicles weighing less than 3000 lbs and those greater than 3000 lbs. The distribution

estimates are based upon the percentages derived from aggregated HSRI Oakland County accident data for the years 1971-1973, reporting approximately 124,000 accidents. In Michigan, reportable accidents were those that resulted in either personal injury or in property damage greater than $200. Accident and injury definitions are taken from the Manual for Classification of Motor Vehicle Traffic Accidents, TAD, Project Bulletin No. 2, National Safety Council, Chicago, Illinois 1970.

It was inferred that 20% of Oakland County vehicles weigh less than 3000 lbs (compared to a nationwide percentage of about 25%). To adjust this bias in the Oakland data, the HSRI accident proportions for each weight category were adjusted to represent the national mix.

These adjusted number of accidents for each car size, classified by severity and urban/rural areas, were added and their respective percentages tabulated in the table that follows. These percentages were then applied to the urban and rural total accidents previously calculated as well as to fatalities and injuries for 1972 (see Appendix A, Tables A.1 and A.2). Fatal and injury accident percentages were assumed to be applicable to fatalities and injuries since there is an approximate linear relationship between number of accidents and people injured or killed.

ADJUSTED PERCENTAGE DISTRIBUTION OF OAKLAND COUNTY
MOTOR VEHICLE TO MOTOR VEHICLE ACCIDENTS
BY VEHICLE WEIGHT

Urban Area

Vehicles Weighing Under 3000 lbs		Vehicles Weighing Over 3000 lbs	
Fatal Accidents	24%	Fatal Accidents	76%
Injury Accidents	22%	Injury Accidents	78%
Property Damage Accidents	21%	Property Damage Accidents	79%

Rural Area

Vehicles Weighing Under 3000 lbs		Vehicles Weighing Over 3000 lbs	
Fatal Accidents	25%	Fatal Accidents	75%
Injury Accidents	23%	Injury Accidents	77%
Property Damage Accidents	23%	Property Damage Accidents	77%

- Collision Direction

The Oakland County data were also tabulated in the following table to indicate the accident percentage-distribution of the primary collision direction (front, side, rear) for the collision vehicle. These percentages were employed in distributing the number of accidents by location (urban/rural) and vehicle weight (under 3000 lbs, over 3000 lbs) into tables showing the accidents, injuries, and fatalities resulting from front, side and rear collisions in 1972 and 1985 (see Appendix A, Tables A.1, A.2, A.15 and A.16).

PERCENTAGE DISTRIBUTION OF OAKLAND COUNTY MOTOR VEHICLE TO MOTOR VEHICLE ACCIDENTS BY PRIMARY COLLISION AREA OF VEHICLE

	Urban Area					
	Vehicles Weighing Under 3000 lbs			Vehicles Weighing Over 3000 lbs		
	Front	Side	Rear	Front	Side	Rear
Fatal Accidents	83.3%	12.5%	4.2%	73.8%	21.4%	4.8%
Injury Accidents	59.8	12.3	27.9	60.2	12.1	27.7
Property Damage Accidents	56.8	11.7	31.5	55.3	13.2	31.5
	Rural Area					
	Vehicles Weighing Under 3000 lbs			Vehicles Weighing Over 3000 lbs		
	Front	Side	Rear	Front	Side	Rear
Fatal Accidents	67.6%	24.3%	8.1%	77.2%	16.8%	6.0%
Injury Accidents	62.8	13.1	24.1	60.4	11.8	27.8
Property Damage Accidents	55.9	11.9	32.2	56.1	13.2	30.7

- Collision Impact Speed

Collision impact speed profiles were constructed using the Multidisciplinary Accident Investigation (MDAI) report file maintained by HSRI; approximately 5,000 cases are contained in this file. Although these files do not contain a cross section of typical accidents, they represent

the only available data which relates impact speed and primary collision area. In addition, the bracketed speeds have been determined by experienced accident investigation teams, in contrast to judgmental estimates made by law enforcement officers (at the time of the accident under difficult conditions) documented in some state reports (e.g., North Carolina). Table 3-24 shows the percentage distribution of accidents by severity of injury and impact speed. These percentages were used to stratify the data shown in Appendix A, Tables A.1 and A.2; the results are tabulated in Tables A.3 through A.14 of Appendix A for 1972 and in Tables A.17 through A.28 for 1985.

- 1985 Forecast of Vehicle-Other Vehicle Accidents

During the review of 1972 vehicle-vehicle accident data, involvement rates (number of drivers in accidents divided by the total number of drivers) for each age group were examined. The rates vary among the age groups, but within each group, the rates have been comparatively stable over recent years. In Section 3.1, it was forecast that annual mileage-per-driver in 1985 would be essentially the same as in 1972. This, along with other supply and demand considerations affecting 1985 usage, suggests the extension of the 1972 involvement rates to the 1985 population mix. For fatal accidents, this can be done directly using the 1972 fatality involvement rates presented previously in Section 3.2, and the projected 1985 population mix from Section 3.1. The resulting figure for 1985 fatal accidents is 23,500 (c.f., 18,900 in 1972).

For injuries and property damage, however, there are adjustments for the differences in definitions discussed in preceding paragraphs. The net effect of this adjustment is to reduce the indicated accident involvement rates to 59% of the figures derived directly from NSC. Upon applying the adjusted involvement rates to the 1985 population mix, the resulting figures for 1985 car to other vehicle accidents are as follows:

Injury Accidents - 3,175,000

Property Damage Accidents - 6,290,000

Table 3-24

Percentage Distribution of Accidents by Severity of Injury and Collision Vehicle Impact Speed

Impact Speed (Mph)	Fatal (%)	Non-Fatal Injury (%)	Property Damage/ Minor Injury (%)
URBAN AREA, PRIMARY DAMAGE: FRONT			
0-20	3	40	69
21-40	42	47	25
41-60	37	10	5
over 60	18	3	1
RURAL AREA, PRIMARY DAMAGE: FRONT			
0-20	7	25	57
21-40	31	48	33
41-60	44	24	7
over 60	18	3	3
URBAN AREA, PRIMARY DAMAGE: SIDE			
0-20	19	57	71
21-40	45	36	25
41-60	28	7	4
over 60	8	0	0
RURAL AREA, PRIMARY DAMAGE: SIDE			
0-20	34	44	61
21-40	28	35	29
41-60	22	17	8
over 60	16	4	2
URBAN AREA, PRIMARY DAMAGE: REAR			
0-20	60	86	93
21-40	40	14	5
41-60	0	0	1
over 60	0	0	1
RURAL AREA, PRIMARY DAMAGE: REAR			
0-20	0	64	79
21-40	67	9	10
41-60	33	27	9
over 60	0	0	2

The 1972 apportionments of these figures between urban and rural environment and between less-than-3000 lb and greater-than-3000 lb were adjusted to reflect the projected increase in urbanization and in the market share of small cars. In 1972, 70% of car-vehicle fatalities were in rural areas. In 1985, the forecasted figure is 64%. It was estimated that 25% of 1972 fatalities were in less-than-3000 lb cars; the corresponding figure for 1985 is 29.5%. The distribution between wet/dry and day/night conditions, plus the distribution of impact points and speeds are assumed to follow the 1972 figures. A summary of these projections with the comparable 1972 figures is shown in Table 3-25. Additional details are given in Appendix A.

Table 3-25

CURRENT AND PROJECTED DATA ON VEHICLE TO OTHER VEHICLE ACCIDENTS ($x10^3$)

	1972			1985		
Variable	F_A	I_A	D_A	F_A	I_A	D_A
Total	18.9	2,588	5,135	23.5	3,175	6,292
Urban	5.5	1,679	3,728	8.5	2,159	4,719
Day	2.3	1,109	2,661	3.5	1,427	3,370
Night	3.2	570	1,067	4.9	732	1,350
Dry	4.3	1,145	2,470	6.6	1,472	3,124
Wet	1.3	534	1,260	1.9	687	1,595
Rural	13.4	908	1.407	15.1	1.016	1.573
Day	5.6	594	997	6.3	664	1,115
Night	7.8	314	410	8.8	352	458
Dry	10.4	620	931	11.6	693	1,041
Wet	3.0	289	476	3.5	323	532

F_A = Fatal Accidents

I_A = Injury Accidents

D_A = Property Damage Accidents

The estimated consequences for the projected baseline 1985 vehicle to other vehicle accidents shown in Table 3-25 are as follows:

	Fatalities	Injuries
Urban	9,100	3,454,000
Rural	20,600	1,808,500
Total	29,700	5,262,500

The corresponding data estimated for 1972 are as follows:

	Fatalities	Injuries
Urban	5,900	2,686,400
Rural	18,300	1,617,000
Total	24,200	4,303,400

Detailed data on fatalities and injuries for 1972 and as projected for 1985 for other accident variables are contained in Appendix A.

Non-Collision Accidents. The definition of non-collision given by the National Safety Council includes deaths in all types of non-collision accidents. Classification is according to first event. If the car runs off the roadway and then strikes a fixed object, death is charged as run-off-road or non-collision accident.

In this section, selected details of this accident category are developed, then a further disaggregation of accident types is made. The fixed object categories are considered in more detail later in this section.

- Fatalities, 1972

Non-collision fatal accidents and fatalities were taken from NSC and were allocated to urban/rural environments in accordance with NSC data.

	Fatal Accidents	Fatalities
Total	13,000	14,400
Urban	2,400	2,600
Rural	10,600	11,800

These data include both the rollover (on- and off-road) and vehicle-fixed object (off-road) categories.

- Injuries, 1972

NSC indicates 230,000 non-fatal injuries were sustained in non-collision accidents (70,000 in urban areas; 160,000 in rural).

Since NSC includes only those injuries considered disabling, it was necessary to calculate a reasonable representation of total injuries in order to correlate with Level 2 and 3 data.

Other sources which were used to determine an average fatal/injury accident ratio follow:

NON-COLLISION ACCIDENTS

Source	Fatal	Injury	Fatal/Injury
New York	829	12,153	1/14.7
North Carolina	727	13,410	1/18.4
National Summary	522	7,190	1/13.8
HSRI	38	718	1/18.9
California (overturn only)	408	9,421	1/23.1

By applying the average value of this fatal/injury ratio (viz., 1.17) to the NSC total of 13,000 Fatal Accidents = 221,000 Injury Accidents (IA).

221,000 IA x 1.5 (I/IA) = 331,500 Injuries

A check of the percentages of Category C injuries occurring in these types of accident reveals:

New York	33.6%
North Carolina	30.8%
California (overturn only)	26.0%

By deducting 30% of injuries as non-disabling; 70% x 331,500 = 232,000 injuries which is consistent with the 230,000 disabling injuries reported by NSC.

The 331,500 injuries were allocated to urban/rural in accordance with the NSC proportions. However, the average number of injuries/accident sustained in rural accidents is considerably larger than those sustained in urban accidents. Therefore, the number of urban and rural injury accidents was adjusted to reflect these differences in the average number of injuries.

The average number of injuries per injury accident obtained from the National Accident Summary and New York and North Carolina state data follow:

All Accidents	1.5
Urban Accidents	1.4
Rural Accidents	1.55

The HSRI day/night proportions for fatal accidents provides only a small number of involvements (38 fatal accidents over this three year period); however, it is apparent from the injury and property damage percentages that higher proportions of this type of accident do occur during hours of darkness. Proportions of 40/60 were selected to apportion fatal, injury and property damage accidents to both urban and rural environments. [31]

An HSRI study, "Analyses of Rollover Accident Factors and Injury Causation", estimates that 63.8% of all "rollover" accidents occur during dawn/dusk and darkness.

The HSRI wet/dry proportions compare favorably with the following NSC statistics, which were used for the allocation.

ACCIDENTS

	Fatal	Injury	All
Dry	77.3	68.2	66.2
Wet	22.7	31.8	33.8

- Property Damage, 1972

A review of all non-collision accidents reveals that approximately 40% of such involvements result in property damage only. These HSRI proportions were selected to portray property damage accident involvement.

HSRI-PROPERTY DAMAGE ACCIDENTS AS A PERCENTAGE OF ALL NON-COLLISION ACCIDENTS

	Total	Urban	Rural	Day	Night	Dry	Wet
Property Damage Accidents	39.5%	35.1%	40.9%	40.2%	39.0%	37.2%	44.2%

This type of accident is considered to be overly represented in North Carolina's total accident environment and under-represented in New York's.

North Carolina statistics indicate 58% of all non-collision accidents result in property damage only and New York's indicate only 26%.

- Summary, Non-Collision Accidents, 1972

HSRI data for three years was used to determine involvement proportions for day/night and dry/wet conditions. These results are shown in the following table.

NON-COLLISION ACCIDENTS
(in percent)

Urban				Rural			
Day		Night		Day		Night	
FA	23.1	FA	76.9	FA	16.0	FA	84.0
IA	38.0	IA	62.0	IA	41.1	IA	58.9
P/D	38.9	P/D	61.1	P/D	40.8	P/D	59.2
Dry		Wet		Dry		Wet	
FA	84.6	FA	15.4	FA	84.0	FA	16.0
IA	68.4	IA	31.6	IA	69.5	IA	30.5
P/D	65.7	P/D	34.3	P/D	62.9	P/D	37.1

These proportions compare well with the NSC dry/wet statistics, which were used for the dry/wet allocation.

	Day	Night	
NSC (fatal motor vehicle accidents, excluding pedestrians)	47.0	53.0	
HSRI (fatal-aggregated urban and rural)	18.4	81.6	(insufficient sample)
HSRI (injury-aggregated urban and rural)	40.3	59.7	
HSRI (property damage)	40.4	59.6	

- A Disaggregation of Non-Collision Accidents

Non-collision accidents are separated into the following three categories in order to determine the proportions of the different types of accidents that are aggregated into this accident category.

1. Rollover (includes both overturning on roadway and running-off-roadway and overturning).

2. Other (includes running off roadway and incurring damage or injury without overturning or striking fixed object, falling out of vehicle, etc.).
3. Striking fixed object (off roadway).

The rollover and other categories are treated in the following paragraphs. The off-road fixed object category is treated in the next subsection entitled, "Collisions with Fixed Objects".

Rollovers. The only rollovers reported by NSC are those that occur on the roadway. All other rollovers are not reported because of their sequence in accident classification events. Thus, if the first event is "ran-off-road" or "collision between vehicles" and the vehicle subsequently overturns, only the first event is recorded.

Since collisions between vehicles has already been classified as a separate subject, this section estimates the number of rollovers that are included in the ran-off-the-road classifications. These estimates are then combined with estimates vehicle rollover on roadway.

The State of California is the only one to report rollovers as a separate accident category, but again, does not differentiate between on and off the road occurrences. NSC, New York, and North Carolina report only those in the "overturned in road" classification as shown below:

	NSC	New York	North Carolina	California
Total Single Vehicle Fatal Accidents	13,000	858	741	1,503
Overturns	540	19	11	408
Percent	3.8	2.2	1.4	27.1

The most comprehensive source available regarding overturns is [31] "Analysis of Rollover Accident Factors and Injury Causation". Findings indicate that of the cases reviewed, only 3% occurred on the roadway, and

that of the remaining 97%, 60% struck another object or vehicle before overturning and 37% ran off the road before overturning. The study concludes that perhaps 19% of all accidents are rollovers.

The results of applying these findings against the NSC data are:

48,800 x 40% x 19% = 3,708 single vehicle overturns

$$\frac{\text{3,708 fatal single vehicle accidents}}{\text{13,000 fatal single vehicle accidents}} = 28.5\%$$

This percentage appears reasonable when compared with the California statistics (27.1%) and will be used to identify overturn accidents. Thus, from the NSC total of 13,000 single-vehicle fatal accidents, 28.5% or 3,705 are identified as rollovers (on- and off-the-road). Fixed-object fatal collisions have been calculated to be 6,840. The remaining 19% or 2,455 are assigned to the other category.

Injury accidents and injuries are allocated in accordance with the ratios discussed previously under Vehicle with Other Vehicle Accidents, i.e., injuries are derived from the observed ratio of fatal/injury accidents (1/17).

Property damage accidents were allocated as follows:

- To fixed objects off-road, in accordance with the proportions from the HSRI data. (25% of all urban property damage accidents, 41% of rural accidents).
- To rollovers, in accordance with findings contained in "Analysis of Rollover Accident Factors and Injury Causation". (15% of rollover accidents do not result in injury). This percentage was selected to portray property damage involvement.

Rollover (on- and off-road) accidents and projections for 1985 for urban/rural, vehicle weight, and speed are as follows:

ROLLOVER ACCIDENTS

	1972			1985		
	FA	IA	PD	FA	IA	PD
TOTAL	3,700	62,985	11,770	4,607	77,283	14,419
Urban:	680	20,520	3,740	847	25,178	4,582
Under 3000 lbs	306	9,234	1,683	381	11,330	2,062
0-30 mph	11	342	62	14	420	76
Over 30 mph	295	8,892	1,621	367	10,910	1,986
Over 3000 lbs	374	11,286	2,057	466	13,848	2,520
0-30 mph	14	418	76	17	512	93
Over 30 mph	360	10,868	1,981	449	13,335	2,427
Rural:	3,020	42,465	8,030	3,760	52,105	9,837
Under 3000 lbs	1,359	19,100	3,610	1,692	23,447	4,427
0-30 mph	50	707	134	62	868	164
Over 30 mph	1,309	18,402	3,480	1,630	22,579	4,263
Over 3000 lbs	1,661	23,356	4,416	2,068	28,658	5,410
0-30 mph	61	864	163	76	1,060	200
Over 30 mph	1,600	22,492	4,253	1,992	27,598	5,210

FA = Fatal Accidents

IA = Injury Accidents

PD = Property Damage Accidents

Collisions with Fixed Objects. Single car accidents, which include collisions with fixed obj-cts and non-collision accidents (overturning and running off the road) pose a particular data source problem. As noted previously, among the various sources reporting these accidents, there are

major differences in definitions. Accident Facts itemizes only those rollovers and fixed object collisions which occur in the roadway; if a car hits a tree off the road, it is classified as a run-off-the-road accident. Other sources of detailed information, e.g., HSRI and the State of California, do not restrict their accident data to on-the-road incidents. Because of the specific needs identified for the RSV program definition phase, the limited definitions and data provided in Accident Facts are not as useful as they were for vehicle to vehicle cases. Accordingly, the approach used was to develop accident data statistics into more comprehensive classifications. The classifications were primarily divided into fixed-object collsion on- and off-the-road, overturning (rollover), and "other". This section first treats the collisions with fixed objects on the road followed by the off-road fixed object single car accidents.

- Fatal and Injury Fixed Object Accidents, On-Road, 1972

The NSC definition of collisions with fixed objects is as follows: "includes deaths from collisions with fixed objects such as walls and abutments, where the collision occurred while all wheels of the vehicle were still on the road."

The NSC data for 1972 includes the following statistics for the victims of fixed-object collisions (no data are indicated for number of accidents).

Deaths:	
Urban	1,900
Rural	2,700
Total	4,600
Non-Fatal Injuries:	
Urban	70,000
Rural	60,000
Total	130,000

From an examination of other source data, the following number of fatalities per fatal fixed-object collision were derived:

National Accident Summary	1.17
California	1.12
New York	1.09
North Carolina	1.38

The National Accident Summary figure was selected as the more representative of a national sample and used with NSC's reported number of fatal accidents. Application of this rationale indicates that there were 3,930 fatal accidents (resulting in the previously noted 4,600 fatalities). Further examination of National Accident Summary data reveals that the number of fatalities differs between urban/rural conditions as follows:

	Urban	Rural
Number of fatalities/ fatal accident	1.14	1.22

HSRI's Oakland County data for the years 1972-1973 were used to indicate the proportions of fixed object collisions occurring in day/night and dry/wet conditions in urban and rural environments. The resulting distribution, shown in Table 3-26, also presents data on injury and property damage accidents.

Table 3-26

PERCENTAGE DISTRIBUTION OF OAKLAND COUNTY FIXED OBJECT ACCIDENTS, ON-ROAD

Variable	Fatal %	Injury %	Damage %
Urban			
Day	18.7	34.4	42.8
Night	81.3	65.6	57.2
Dry	81.3	61.2	57.8
Wet	18.7	38.8	42.2

Table 3-26 (Cont'd)

Variable	Fatal %	Injury %	Damage %
Rural			
Day	23.3	35.4	40.9
Night	76.7	64.6	59.1
Dry	72.1	54.2	47.7
Wet	27.9	45.8	52.3
All Areas			
Day	21.3	34.8	42.0
Night	78.7	65.2	58.0
Dry	76.0	58.0	53.4
Wet	24.0	42.0	46.6

It is noted that a larger proportion of fixed object collisions occur at night and that although the percentage of fatal accidents occurring on wet road surfaces coincides with the NSC percentage of 22.7, the wet proportions for injury and property damage accidents are considerably above those found for other accident types.

In order to estimate the number of injury accidents and injuries that resulted from collisions with fixed objects, a review similar to that used on other sections was instituted. Because of the wide divergence found in fatality to injury and injury to accident ratios, together with an inability to correlate data from the various sources because of differences in definition (i.e., California does not classify running-off-the-road as an accident, therefore, collisions with an off-the-road object would not be included in their statistics), the National Accident Summary ratio was selected as most representative and applied to the number of fatal accidents to determine the number of fixed object injury accidents.

Injuries were allocated to urban/rural environment in accordance with the proportions estimated by NSC for non-fatal injuries. Total injuries and allocation of injury accidents to urban/rural were in accordance with averages from the National Accident Summary.

	Urban	Rural
Number of injured victims/fixed object collisions	1.34	1.51

These figures are consistent with comparable ratios from state files.

Tables 3-27, 3-28, and 3-29 provide the information on fatalities and injuries; the number of collisions and light and weather conditions associated with fixed object accidents.

Table 3-27

FATAL AND INJURY ACCIDENT DATA - FIXED OBJECTS, ON-ROAD

Source	Ratio of Fatal to Injury Accidents
National Accident Summary	1/55
New York State	1/121
North Carolina	1/24
California	1/23
HSRI/Oakland County (Michigan)	1/44

Table 3-28

1972 MOTOR VEHICLE COLLISION WITH FIXED OBJECT ACCIDENT DATA, ON-ROAD

Data	Urban	Rural	Total	Source
Fatalities (1)	1,900	2,700	4,600	NSC
Fatalities ÷ Fatal Accidents (2)	1.14	1.22		NSC
Fatal Accidents	1,667	2,213	3,880	(1) x (2)
Injury Accidents (3)	91,685	121,715	213,400	Fatal Accidents x 55, National Accident Summary
Injuries ÷ Injury Accidents (4)	1.34	1.51		National Accident Summary
Injuries	122,858	183,790	306,648	(3) x (4)
Property Damage Accidents (PDA)	248,364	192,780	441,144	HSRI: $\frac{PDA_{TOTAL}}{PDA_{TOTAL}+3880+213,400} = .67$ $PDA_{URBAN} = .563\ PDA_{TOTAL}$

Table 3-29

1972 MOTOR VEHICLE COLLISION WITH FIXED OBJECT, ON-ROAD, ACCIDENTS BY LIGHT AND WEATHER CONDITIONS*

	LIGHT CONDITIONS			
	Urban		Rural	
	Day	Night	Day	Night
Fatal Accidents	312	1,588	516	2,184
Injury Accidents	31,540	60,145	43,087	78,628
Property Damage Accidents	106,300	142,064	78,847	113,933
Fatalities	355	1,545	629	2,071
Injuries	42,263	80,595	65,062	118,728
	WEATHER CONDITIONS			
	Dry	Wet	Dry	Wet
Fatal Accidents	1,355	322	1,596	617
Injury Accidents	56,111	35,574	65,970	55,745
Property Damage Accidents	143,554	104,810	91,956	100,824
Fatalities	1,545	355	1,947	753
Injuries	75,189	47,669	99,614	84,176

*Fatal and injury accident percentages from Table 3-26 assumed to be applicable to fatalities and injuries as well.

- Fixed Object, On-Road, Property Damage, 1972

To determine property damage-only accidents resulting from collisions with fixed objects, the various sources were again reviewed:

	HSRI Oakland County	New York State	North Carolina State	National Accident Summary
Property Damage Accidents as a Percentage of All Fixed Object Collisions	69%	41%	69%	83%

HSRI percentages which were from the only source separating vehicle size and damage were then used to portray property damage accident involvement. Percentages for vehicle size involvement, derived from the Oakland

County files (1971-1973) on motor vehicle collisions with fixed objects (see Table 3-26), were applied to the data in Table 3-30. The resulting frequencies (number of accidents, fatalities, and injuries) by location and vehicle size for 1972 are shown in Appendix C, Tables C.1 and C.2.

Table 3-30

PERCENTAGE DISTRIBUTION OF OAKLAND COUNTY MOTOR VEHICLE WITH FIXED OBJECT, ON-ROAD, ACCIDENTS BY ACCIDENT SEVERITY AND VEHICLE WEIGHT

	Vehicle Weight Under 3000 lbs	Vehicle Weight Over 3000 lbs
	Urban Area	
Fatal Accidents	25.0%	75.0%
Injury Accidents	24.6	75.4
Property Damage Accidents	19.1	80.9
	Rural Area	
Fatal Accidents	44.4%	55.6%
Injury Accidents	26.9	73.1
Property Damage Accidents	24.0	76.0

Fixed object accidents were apportioned among the primary collision areas using percentages derived from 1971-1973 Oakland County data (see Table 3-31).

Table 3-31

PERCENTAGE DISTRIBUTION OF OAKLAND COUNTY ACCIDENTS (1971-1973) BY VEHICLE PRIMARY COLLISION AREA

	Vehicle Weight Under 3000 lbs			Vehicle Weight Over 3000 lbs		
	Front	Side	Rear	Front	Side	Rear
			Urban			
Fatal Accidents	100%	*	*	100%	*	*
Injury Accidents	85.3	9.9%	4.8%	89.6	6.5%	3.9%
Property Damage Accidents	74.1	10.0	15.9	70.8	7.7	21.5
			Rural			
Fatal Accidents	62.5%	31.3%	6.2%	74.1%	25.9%	*
Injury Accidents	80.6	13.9	5.5	84.1	10.9	5.0%
Property Damage Accidents	75.3	11.4	13.3	74.4	11.1	14.5

*Negligible

The MDAI file data were used to derive percentage distribution of bracketed collision impact speeds for motor vehicle to fixed object accidents. The corresponding accident frequencies by impact speed, accident locations, vehicle impact area, and vehicle size for 1972 are listed in Tables C.3 through C.14 in Appendix C.

- Fixed Object Accidents, On-Road, 1985

From regional data, there is evidence that collisions with fixed objects follow a pattern of age involvement similar to vehicle-vehicle collisions. Accordingly, projections of the 1985 accidents and victims were made using the same rates of increase shown previously in the vehicle-vehicle category. The results applied to fixed object collisions are shown in Tables 3-32, 3-33 and 3-34.

Table 3-32

PROJECTED 1985 MOTOR VEHICLE WITH FIXED OBJECT ACCIDENTS, ON-ROAD

	1972 Occurrence	Ratio 1985 to 1972 Occurrence	Projected 1985 Occurrence
	(1)	(2)	(1) x (2)
Fatal Accidents	3,880	1.245	4,831
Injury Accidents	213,400	1.227	261,842
Property Damage Accidents	441,144	1.225	540,401
Fatalities	4,600	1.245	5,727
Injuries	306,648	1.227	376,257

The allocation of the projected accidents between urban and rural locales and between vehicle weight categories is based upon the 1972 apportionments, with a correction for increased urbanization and larger market share for smaller cars (these proportionate adjustments are identical to those developed previously for car with other vehicle). The results are summarized in Tables 3-33 and 3-34 with additional detail in Appendix C, Tables C.1 and C.2. The 1985 percentage distributions for bracketed impact speeds and impact area are assumed to be similar to the 1972 MDAI distributions.

Accident frequencies by impact speed, vehicle impact area, location (urban-rural) and vehicle weight are given in Tables C.17 through C.28 in Appendix C.

Table 3-33

1985 MOTOR VEHICLE COLLISION WITH FIXED OBJECT ACCIDENTS, ON-ROAD, BY LOCATION

	Urban Area	Rural Area
Fatal Accidents	2,416	2,415
Injury Accidents	120,447	141,395
Property Damage Accidents	313,432	226,969
Fatalities	2,749	2,978
Injuries	161,791	214,466

Table 3-34

1985 MOTOR VEHICLE COLLISION WITH FIXED OBJECT ACCIDENTS, ON-ROAD, BY LIGHT AND WEATHER CONDITIONS

	LIGHT CONDITIONS			
	Urban		Rural	
	Day	Night	Day	Night
Fatal Accidents	452	1,964	563	1,852
Injury Accidents	41,434	79,013	50,053	91,342
Property Damage Accidents	134,149	179,283	92,830	134,139
Fatalities	514	2,235	694	2,284
Injuries	55,656	106,135	75,920	138,546
	WEATHER CONDITIONS			
	Dry	Wet	Dry	Wet
Fatal Accidents	1,964	452	1,741	674
Injury Accidents	73,714	46,733	76,636	64,759
Property Damage Accidents	181,164	45,805	108,264	118,705
Fatalities	2,234	515	2,147	831
Injuries	93,515	68,276	116,241	98,225

- Fixed Objects, Off-Road

The previous section discussed collisions with fixed objects where the collision occurred while all wheels of the vehicle were still on the road. Segregation of these types of fixed object collisions is necessary due to accident reporting classifications and is desirable because the on-road accidents will presumably benefit from roadway hazard elimination.

The estimate of the number of off-road fixed object collisions that are included in the non-collision classification necessitates that projections be derived from fatality accidents. A summary from several sources follows:

SUMMARY OF FATAL ACCIDENTS, 1972

	NSC	%	New York	%	North Carolina*	%	Calif.	%
Total Motor Vehicle	36,050	100	1,919	100	1,293	100	3,595	100
Two-Vehicle	18,900	52.4	906	47.2	539	41.7	1,678	46.7
Fixed Object	4,150	11.5	155	8.1	13	1.0	1,024	33.5
Non-Collision	13,000	36.1	858	44.7	741	57.3	712	19.8

Note: New York and North Carolina report fixed object and non-collision accidents in accordance with NSC definitions; California does not.

*As noted previously, North Carolina's non-collision experience is not representative.

By adding fixed object and non-collision percentages, some similarity in proportions of single vehicle accidents appears despite use of different definitions for classification.

NSC	47.6%
New York	52.8
North Carolina	58.3
California	53.3

California is the only source found that reports fixed object collisions as a separate classification and does not differentiaate between on- and off-road occurrences. Since there is no reason for California to differ significantly from the national mean for on-road occurrence, the assumption is made that the national ratio of fatal accidents involving fixed objects on roadway divided by total fatal accidents (which equals 11.5%) is applicable to California. This translates to 413 California fatal accidents involving the striking of an on-road fixed object. Deducting this figure from California's total

reported fixed-object fatal accidents of 1,204, indicates that 65.7% of California's fixed object fatal collision involvement occur off-road.

By adding this estimated off-road fixed object involvement to a single vehicle category, a closer similarity among sources is observed.

SINGLE VEHICLE ACCIDENTS AS A PERCENTAGE
OF ALL MOTOR VEHICLE ACCIDENTS

NSC	36.1
New York	44.7
California	41.8

Then, assuming that this (California's) off-road fixed object involvement rate of 52.6% is representative of national conditions indicates the accident distribution:

CALIFORNIA ACCIDENTS, 1972

Total Single Vehicle	1,503
Off-Road Fixed Object	791 or 52.6%

Application of 52.6% to NSC's Single Vehicle Fatal Accident total of 13,000 then assigns 6,840 accidents to off-road fixed object collisions.

The distribution of off-road motor vehicle to fixed object accidents by weather conditions, light conditions, vehicle weight, collision area of vehicle, and impact speed should not be significantly different from on-road accidents. Accident frequencies for 1972 off-road accidents for various combinations of circumstances may then be computed by applying the factors derived in Table 3-35 to the 1972 on-road values contained in Appendix C. Having calculated the 1972 frequencies, the factors developed in Table 3-36 may be applied to the 1972 off-road estimates to calculate the 1985 accident, fatality and injury levels for off-road fixed object collisions.

Table 3-35

FACTORS FOR CALCULATING 1972 OFF-ROAD MOTOR VEHICLE TO FIXED OBJECT ACCIDENT DATA

	On-Road (1)	Off-Road (2)	Factor [(2) ÷ (1)]
		Urban	
Fatal Accidents	1,667	1,260	.75585
Injury Accidents	91,685	37,870	.41304
Property Damage Accidents	248,364	21,070	.08484
Fatalities	1,900	1,370	.72105
Injuries	122,858	53,020	.43156
		Rural	
Fatal Accidents	2,213	5,575	2.51930
Injury Accidents	121,715	78,375	.64392
Property Damage Accidents	192,780	58,340	.30262
Fatalities	2,700	6,205	2.29815
Injuries	183,790	121,350	.66026

Table 3-36

FACTORS FOR CALCULATING OFF-ROAD MOTOR VEHICLE TO FIXED OBJECT ACCIDENT DATA

	Urban and Rural		
	1972 On-Road Occurrences (1)	1985 On-Road Occurrences (2)	Factor [(2) ÷ (1)]
Fatal Accidents	3,880	4,831	1.245
Injury Accidents	213,400	261,842	1.227
Property Damage Accidents	441,400	540,401	1.225
Fatalities	4,600	5,727	1.245
Injuries	306,648	376,257	1.227

Application of the factors from Table 3-36 gives the following distribution of off-road fixed object accidents for 1985:

	Urban	Rural
Fatal Accidents	1,568	6,940
Injury Accidents	46,466	96,166
Property Damage Accidents	25,810	71,465
Fatalities	1,705	7,725
Injuries	65,055	148,900

Pedestrian Accidents

- Fatalities, 1972

NSC data is used to characterize pedestrian fatal accidents and numbers of fatalities, together with their allocations to urban/rural and day/night conditions.

A review of NSC data for the past ten years indicates there have been no significant changes in the proportions of pedestrian fatalities occurring in urban and rural environments, or during day and night conditions. Figure 3-32 provides historical information regarding urban and rural proportions.

- Pedestrian Injuries, 1972

The data obtained for pedestrian injuries are subject to the same definitional problems noted in previous discussions. NSC assigns non-disabling injuries to the property damage category and indicates a consistent historical portion of about 150,000 pedestrian injuries per year, until 1972 when, due to a classification change, the number of injuries dropped to 120,000. In 1972, a total of 130,700 pedestrian deaths and injuries and 400,000 pedestrian accidents are indicated by the National Safety Council.

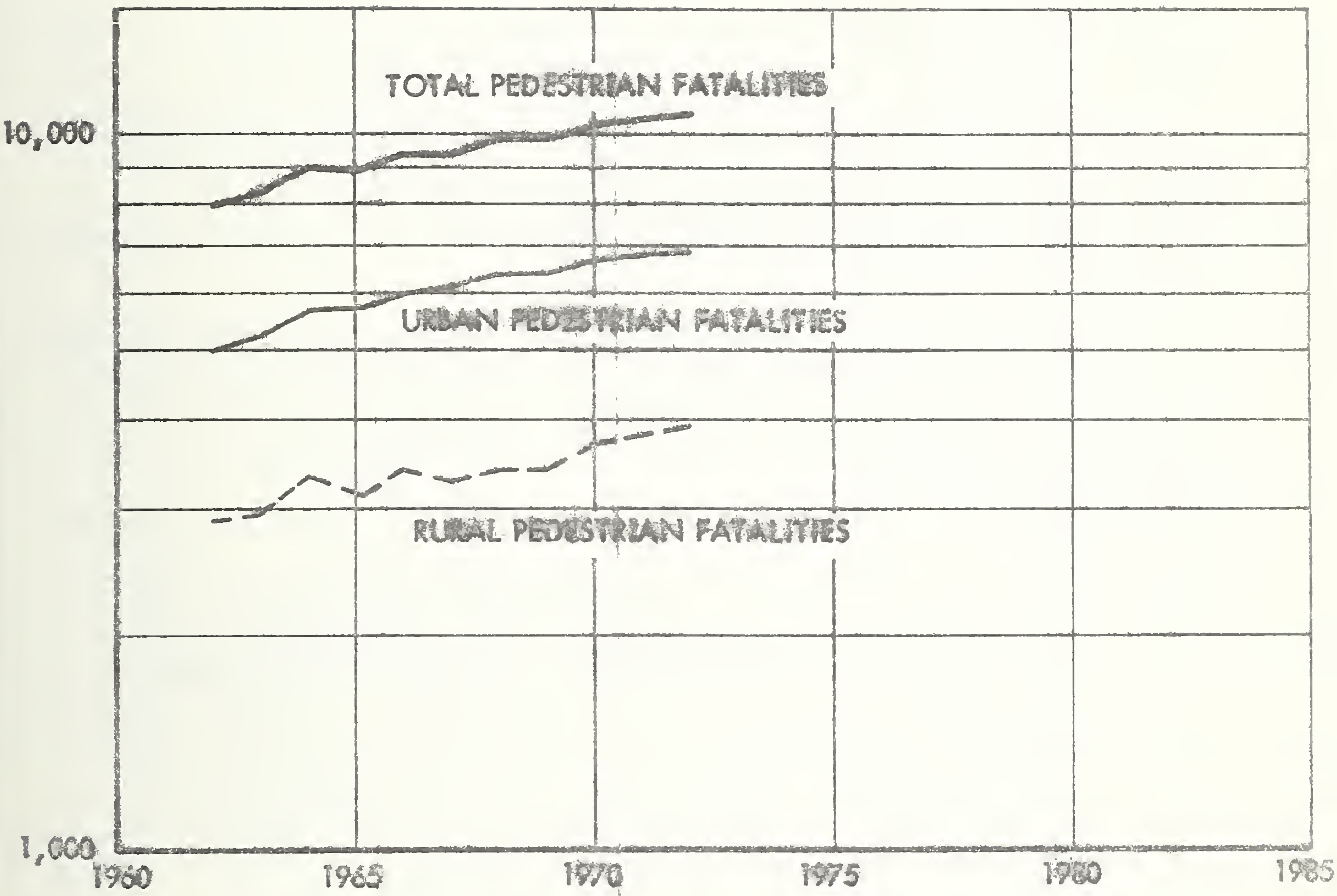


Figure 3-32. Pedestrian Fatalities, 1962-1972

Other source data were also examined to determine the percentage of pedestrian injuries that were categorized non-disabling and excluded from the NSC injury count.

	% of Injuries Category C
New York	57.0
North Carolina	18.3
California	27.7

It can be seen that even after applying the percent factors from New York (with the largest number of pedestrian involvements in the nation) there is no real explanation to account for NSC's 400,000 pedestrian involvements.

The Travelers Insurance Company's "Book of Street and Highway Accident Data" indicates 277,000 pedestrian injuries were sustained during 1972. This statistic was selected as appropriate baseline information after the following analysis was made.

The ratio of fatal-injury accidents from the other sources includes the following:

	Pedestrian Accidents, 1972		
	Fatal	Injury	Ratio (F/I)
California	833	12,453	1:14.9
Oakland Co., Michigan	76	1,156	1:15.2
North Carolina	362	2,149	1:5.9
New York	903	23,197	1:25.7

These sources were also examined for information regarding number of injuries sustained in each pedestrian injury accident with the following result.

PEDESTRIAN ACCIDENTS, 1972

	Injury Accidents	Injured Persons	Average No. of Persons Injured
California	12,453	13,364	1.07
North Carolina	2,149	2,418	1.13
New York	23,197	24,278	1.05

By selecting a factor of 1.06 persons injured (the approximate mean of California and New York) per pedestrian injury accident and applying it to the 277,000 pedestrian injuries, a total of 261,320 injury accidents is obtained. This would result in a fatal/injury accident ratio of:

261,320 ÷ 10,500 fatal pedestrian accidents = 1:24.9

The detailed information available in the Oakland County file was then used to indicate the prevailing conditions when pedestrian injury accidents occur, as shown in the following table.

HSRI-OAKLAND COUNTY MICHIGAN PEDESTRIAN
ACCIDENTS, FATAL AND INJURY

	Total		URBAN		RURAL	
F	76		47	(61.8%)	29	(38.2%)
I	1,139		791	(60.4%)	348	(30.6%)

	URBAN DAY		URBAN NIGHT		RURAL DAY		RURAL NIGHT	
F	18	(38.3%)	29	(61.7%)	8	(27.6%)	21	(72.4%)
I	576	(72.8%)	215	(27.2%)	254	(73.0%)	94	(27.0%)

	URBAN WET		URBAN DRY		RURAL WET		RURAL DRY	
F	13	(27.7%)	34	(72.3%)	8	(27.6%)	21	(72.4%)
I	187	(23.6%)	604	(76.4%)	80	(23.0%)	268	(77.0%)

The sample size of fatal accidents is not sufficient for accurate representation, especially as fatalities are allocated down the tree, although the fatal urban/rural proportions do compare favorably with the 64.8/35.2 percentages found in NSC data when considering that Oakland County is slightly less urban than the nation's average. The proportions of injury accidents

occurring during night/day and wet/dry conditions compare favorably with other data. Operations Research Inc. in their "Pedestrian Safety Study, 1971" investigated 1,636 pedestrian injury accident cases from 13 major urban areas: 75.7% occurred during daylight hours, 24.3% during darkness. It is noteworthy that day/night percentages remain relatively constant regardless of urban and rural environment.

There are little or no data available to relate pedestrian fatalities to vehicle weight category (the HSRI data did not include a sufficient sample). Thus, pedestrian fatalities and fatal accidents involving motor vehicles were subdivided by collision vehicle weight using the same percentages derived previously for motor vehicle to motor vehicle fatal accidents.

The HSRI/Oakland County file does include a sufficient number of injury accidents (approximately 1400) recorded from 1971 to 1973 to justify use of a derived percentage distribution of injury accidents according to collision vehicle weight (see Table 3-37). The accident figures for 1972 in Tables B.1 and B.2 of Appendix B were then calculated. The comparable figures for 1985, Tables B.43 and B.44 of Appendix B, were computed using the same involvement percentages used in the 1985 projections for motor vehicle to motor vehicle accidents (this includes an appropriate adjustment for increase in small car market share).

The number of fatalities/fatal accidents and injuries/injury accidents to pedestrians caused by the front, side and rear of the collision vehicle was based on the Oakland County accident data files. These percentages, tabulated in Table 3-38, are reasonable for 1972 patterns and 1985 projections; the resulting accident figures are shown in Appendix B, Tables B.1, B.2 and B.43, B.44 respectively.

Table 3-37

ADJUSTED* PERCENTAGE DISTRIBUTION OF PEDESTRIAN INJURY ACCIDENTS OCCURRING IN CAKLAND COUNTY, 1971-1973 BY COLLISION VEHICLE WEIGHT

	Collision Vehicles Weighing Under 3000 lbs		Collision Vehicles Weighing Over 3000 lbs	
Urban Area				
	Injury Accidents	22.3%	Injury Accidents	77.7%
Rural Area				
	Injury Accidents	23.1%	Injury Accidents	76.9%

*See motor vehicle to motor vehicle accident discussion for explanation.

Table 3-38

PERCENTAGE DISTRIBUTION OF OAKLAND COUNTY MOTOR VEHICLE WITH PEDESTRIAN ACCIDENTS BY COLLISION AREA OF VEHICLE

	Vehicles Under 3000 lbs			Vehicles Over 3000 lbs		
	Front	Side	Rear	Front	Side	Rear
Urban Area						
Fatal Accidents	100%	*	*	92.8%	2.4%	4.8%
Injury Accidents	86.3	8.6%	5.1%	86.2	7.9	5.9
Rural Area						
Fatal Accidents	100%	*	*	92.6%	*	7.4%
Injury Accidents	90.3	8.1%	1.6%	82.3	13.4%	4.3

*Negligible

Collision speed profiles for fatal and injury accidents involving pedestrians were obtained from a study which analyzed 2,158 cases from [32] 13 different areas which reported 42,500 pedestrian accidents in 1968. The bracketed speed frequencies are given in Table 3-39; these frequencies were used to calculate Tables B.3 to B.14 and B.45 to B.56 which show 1972 and 1985 pedestrian accidents by location, vehicle size, vehicle collision area and impact speed.

Table 3-39

PERCENTAGE DISTRIBUTION OF PEDESTRIAN ACCIDENTS BY SEVERITY OF INJURY VEHICLE IMPACT SPEED

	Front and Side Collisions*		
	0-20 mph	21-40 mph	over 40 mph
Fatal Accidents	40.0%	49.7%	10.4%
Injury Accidents	58.5	40.5	1.0
	Rear Collisions		
Fatal Accidents	100%	0	0
Injury Accidents	100%	0	0

*Speed distribution reported in source document were assumed to apply to front and side collisions while all rear collisions were assumed to occur under 20 mph.

- Pedestrian Accidents, 1985

Historical data of pedestrian fatalities and injuries by victim age group were compiled (see Tables 3-40 and 3-41) in order to provide 1972 baseline information and also to discern apparent trends in age involvement patterns as a result of the nation's changing age structure. The 1972 NSC, New York and California statistics are shown in Table 3-42.

Table 3-40

PEDESTRIAN FATALITIES BY AGE OF VICTIM*

(Percent*)

Year	Under 5	5-14	15-24	25-44	45-64	Over 64
1960	14.2	15.5	5.8	13.5	21.3	29.7
1961	13.7	15.0	6.3	13.3	20.9	30.7
1962	12.7	19.0	6.6	10.9	20.5	30.4
1963	12.6	17.7	8.5	13.4	21.0	26.8
1964	11.7	16.8	8.9	14.0	22.3	26.3
1965	11.9	16.5	9.1	14.8	21.6	26.1
1966	11.3	17.7	9.7	14.5	21.5	25.3
1967	11.2	18.1	10.1	12.8	20.2	27.7
1968	9.7	10.4	9.7	13.8	20.9	26.5
1969	10.2	18.4	10.7	14.8	21.4	24.5
1970	7.7	18.3	12.0	14.4	20.6	26.0
1971	7.5	18.9	13.2	15.1	20.8	24.5
1972	7.5	18.7	13.1	15.0	21.5	24.3

SOURCE: National Safety Council

*Percentages are summed along rows; they may not add to 100 due to rounding errors.

Table 3-41

PEDESTRIAN INJURIES BY AGE OF VICTIM*

(Percent*)

Year	Under 5	5-14	15-24	25-44	45-64	Over 64
1960	19.2	38.5	7.7	11.5	11.5	11.5
1961	20.8	37.5	8.3	12.5	12.5	8.3
1962	17.7	42.3	9.2	10.0	12.3	8.5
1963	17.0	39.3	11.1	11.9	12.6	8.2
1964	16.4	36.4	11.4	13.6	12.9	9.3
1965	15.7	37.1	12.9	14.3	12.1	7.9
1966	15.3	38.7	12.7	14.0	12.0	7.3
1967	16.0	39.3	13.3	12.0	11.3	8.0
1968	13.3	41.3	13.3	12.7	11.3	8.0
1969	13.3	40.7	14.0	12.7	11.3	8.0
1970	11.3	39.4	15.6	12.5	12.5	8.6
1971	10.0	40.0	16.7	14.2	11.6	7.5
1972	10.0	40.0	16.7	14.2	11.6	7.5

SOURCE: National Safety Council

*Percentages are summed along rows; they may not add to 100 due to rounding errors.

Upon comparing the historical trend information in Tables 3-40 and 3-41 with population data, it was noted that the number of pedestrian accidents in age groups under 24 years was closely related to their numbers within the nation's population. The forecast of 1985 accidents is based upon population in these age groups as indicated in Figure 3-33.

Numbers of victims by age groups were then applied to the nation's 1972 age structure in order to determine age group involvement rates (see Table 3-43).

The 1972 age group involvement rates were applied to the nation's 1985 age structure to provide a baseline forecast of pedestrian involvement (see Table 3-44).

Motorcycle Accidents

- Accidents, 1972

Motorcycle accident statistics are included in the various types of motor vehicle accidents discussed in previous sections. In this section, motorcycle data are segregated from the overall motor vehicle accidents. Of concern are only those involvements occurring within the highway system, i.e., "field-bike" accidents are not included.

The NSC considers only the number of motorcycles involved in fatal accidents and all accidents, and the number of motorcycle rider deaths. 1972 data follows:

Number of motorcycles involved in fatal accidents	2,800
Number of motorcycles involved in all accidents	343,000
Number of motorcycle rider deaths	2,700

Historical statistics were examined to determine if there was a direct relationship between the number of rider deaths and the number of registered motorcycles. Some relationship over time can be seen but is not considered conclusive because of changes in registration requirements among

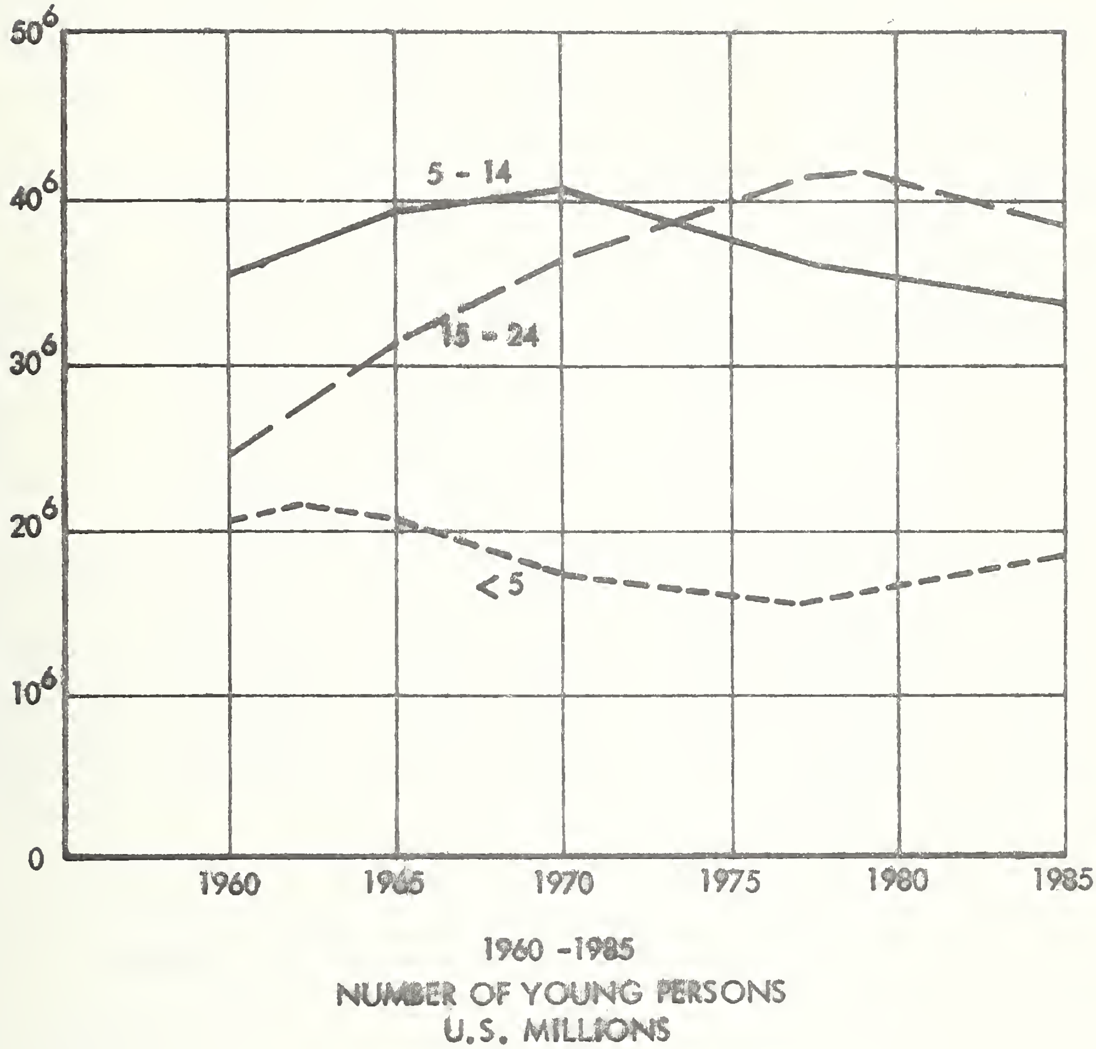


Figure 3-33. Projected Population of Age Groups Under 24 Years Old

Table 3-42

PERCENTAGE PEDESTRIAN INVOLVEMENT BY AGE OF VICTIM, 1972*

Age, Years:	Under 5	5-14	15-24	25-44	45-64	Over 65
FATALITIES						
NSC	7.5%	18.7%	13.1%	15.0%	21.5%	24.3%
New York State	4.0	13.9	11.7	13.8	24.1	32.5
California	10.1	13.8	13.7	14.0	21.7	26.8
INJURIES						
NSC	10.0	40.0	16.7	14.2	11.6	7.5
New York State	7.2	37.8	17.5	16.1	12.7	8.6
California	11.2	34.6	17.8	15.0	12.1	9.2

*Distribution of victims by age group percentages may not add to 100 due to rounding.

Table 3-43

1972 PEDESTRIAN INVOLVEMENT

	Population 10^3	Fatalities	Involvement per 100,000	Injuries	Involvement per 100,000
TOTAL	208,837	10,700		277,000	
Under 5	17,242	800	4.64	27,700	160.65
5-14	39,506	2,000	5.06	110,000	280.46
15-24	38,320	1,400	3.65	46,260	120.72
25-44	50,126	1,600	3.19	39,330	78.46
45-64	42,695	2,300	5.39	32,130	75.25
Over 64	20,949	2,600	12.41	20,780	99.19

Table 3-44

1985 BASELINE FORECAST OF PEDESTRIAN ACCIDENTS

	Population	Fatality Involvement Rate per 100,000	Fatalities	Yearly Involvement Rate per 100,000	Injuries
TOTAL	230,913		11,776		282,800
Under 5	18,055	4.64	838	160.65	29,000
5-14	33,517	5.06	1,696	280.46	94,000
15-24	38,023	3.65	1,388	120.72	45,900
25-44	71,991	3.19	2,297	78.46	56,500
45-64	43,402	5.39	2,340	75.25	32,700
Over 64	25,924	12.41	3,217	99.19	25,700

various states; it was impossible to segregate on-road from off-road vehicles. Therefore, increases in registrations cannot be directly translated to increased highway use. Table 3-45 shows yearly changes in motorcycle registrations and rider deaths.

Table 3-45

MOTORCYCLE HISTORICAL DATA

	Motorcycle Registration		Motorcycle Rider Deaths	
Year	Number	Yearly % Change	Number	Yearly % Change
1960	575,497		731	
1961	595,669	+ 3.5	697	- 4.7
1962	660,400	+10.9	759	+ 8.9
1963	786,318	+19.1	882	+16.2
1964	964,763	+25.2	1,118	+26.8
1965	1,381,956	+40.3	1,515	+35.5
1966	1,752,801	+26.8	2,043	+34.9
1967	1,953,022	+11.4	1,971	- 3.5
1968	2,100,547	+ 7.6	1,900	- 3.2
1969	2,315,916	+10.3	1,960	+ 3.2
1970	2,814,730	+21.5	2,330	+18.9
1971	3,345,179	+18.8	2,410	+ 3.4
1972	3,787,000	+13.2	2,700	+16.2
1973	4,222,000	+11.0	3,130	+15.9

An examination of motorcycle accident statistics (shown in the next table) from the states of California, New York, Washington and North Carolina indicates that a reasonable portrayal of motorcycle involvement can be set forth.

By eliminating property damage classifications (which in motorcycle involvement results to less than 10% of total accidents), there appears to be consistency among sources as to the proportions of fatal/injury accident involvement, and in the case of California, fatalities/injuries.

MOTORCYCLE ACCIDENT STATISTICS

	Total Fatal & Injury Accidents	Fatal Accidents	Injury Accidents	Ratio Fatal/Injury
North Carolina	2,110	69	2,041	1:30
Row%	100%	3.3	96.7	
New York	4,883	127	4,756	1:37
Row %	100%	2.6	97.4	
California	20,908	584	20,324	1:35
Row %	100%	2.8	97.2	

California and New York, combined in 1972 accounted for approximately 18.5% of the nation's motorcycle population and 26.3% of the motorcycle fatalities. The 1972 U.S. total motorcycle registrations were 3,787,300; in 1972 California had 615,000 registrations and New York 87,000.

A review of state data sources indicates fatal/injury proportions of approximately 1:35. By applying these proportions to the 2,700 motorcycle rider fatalities, it is calculated that approximately 94,500 injuries were sustained in highway associated motorcycle accidents during 1972. This number appears reasonable when considering California's percentage of the nation's fatalities and number of injuries.

The data do not provide a basis to assign an occupancy factor to estimate an average number of persons killed or injured in fatal or injury accidents. Therefore, an assumption was made that each motorcycle accident results in one victim.

New York, North Carolina and Washington allocate motorcycle accidents to urban/rural environments as shown:

	Urban	Rural
New York		
Fatal Accidents	36.2%	63.8%
Injury Accidents	49.5	50.5
North Carolina		
Fatal Accidents	24.6	74.5
Injury Accidents	47.4	52.6
Washington (Fatal Acc.)	16.7	83.3

In addition, California allocates motorcycle fatalities and injuries to incorporated and unincorporated areas as shown:

	Incorporated	Unincorporated
Fatalities	54.6	45.5
Injuries	67.9	32.1

The only available information regarding motor vehicle accidents during day/night conditions was found in an analysis of 1,230 motorcycle accidents occuring in North Carolina during the years 1966-1967. This analysis found that 67.6% of the accidents studied occurred during daylight hours, with different proportions for single or two vehicle accidents as shown below:

	Day	Night
Total	67.6	32.4
Single Vehicle	61.8	38.2
Two Vehicle	70.7	29.3

- Type of Collision

The North Carolina analysis found that approximately 65% of motorcycle collisions involved another vehicle, mainly passenger cars. This information is consistent with that found in another reference where 63% of the motorcycle crashes studied also involved another motor vehicle, mainly passenger cars.

California's 1972 statistics indicate that 60% of motorcycle drivers involved in fatal accidents and 69% of those involved in injury accidents were in multi-vehicle collisions. These same statistics contain information as to type of collision by area of impact, but do not differentiate between the involved vehicles. Areas of impact in multi-vehicle collisions in which motorcycles are involved are shown in the following table.

Area of Impact	Fatal	Injury
Front	25.6%	10.6%
Side	57.7	70.0
Rear	16.7	19.4
TOTAL	100	100

As shown below, if one is involved in a motorcycle injury accident, there is an 80% chance that the injuries will be more severe than Category C, minor injuries.

CALIFORNIA, 1972

Type Accident	Total Injured	Category C Injuries	C/Total %
Motor vehicle driver	138,455	57,508	41.5
Passenger	89,198	42,235	47.3
Pedestrian	13,933	3,964	28.5
Bicyclist	10,843	2,943	27.1
Motorcyclist	20,324	3,954	19.5

- Sex and Age Involvement

A review of motorcycle accident statistics and studies indicates that sex and age are the two principal influencing factors on accident rates.

Motorcycle operators are predominantly male. Examination of the results of eight different surveys reveals that in each case, over 95% of the operators were males (an average of the surveys indicates 97% males). This male predominance is borne out of the following involvement statistics. The California data indicates victims only. It is assumed that the higher proportion of females is due to occupant victims.

MOTORCYCLE ACCIDENT INVOLVEMENT AND SEX OF DRIVER
(1972)

	Male	Female
Washington		
Drivers in all accidents	97.6	2.4
Drivers in fatal accidents	95.7	4.3
California		
Fatal victims	88.9	10.1
Injury victims	88.4	11.6

As shown below, approximately two thirds of the accidents reported by these two sources involve the 15-24 age group.

MOTORCYCLE ACCIDENT INVOLVEMENT AND AGE OF DRIVER
(percentages)

	15-24	25-34	35-45	Over 45
Washington				
Drivers in all accidents	73.0	19.2	4.2	3.6
Drivers in fatal accidents	60.9	17.3	10.8	11.0

	Under 15	15-24	25-34	35-45	Over 45	Total
California						
Fatal victims	2.6	59.3	24.3	8.0	5.9	100%
Injury victims	4.0	66.2	20.8	5.6	3.5	100%

The data presented above does not allow further breakout among age groups; however, it is felt that those of ages 25 through 29 are responsible for approximately 75% of the involvements assigned to the 25-34 age group. From the preceding, it is estimated that males represent approximately 97% of the motorcycle operator population, and that their accident

involvement is in line with that proportion. Further, the age groups under 30 are responsible for approximately 85% of motorcycle accident involvement. These proportions are used to formulate the following distribution by age for baseline information.

1 9 7 2

Age Group	Age Distribution Fatal Accidents	Age Distribution Injury Accidents
15-24	65%	70%
25-29	15	15
30-34	5	8
35-44	7	4
44-64	8	3
	100	100

Although their overall involvement rates are low, survivability decreases with age. This is apparent from the increased proportions shown in Table 3-46.

These age group involvement percentages were applied to 1972 numbers of fatal and injury accidents to calculate the number of accidents occurring to each age group. These numbers were then divided by the number of males in each group in order to determine an involvement rate per 100,000 population, see Table 3-46. For purposes of calculating these rates, the approximately 3% of motorcycle accidents involving female drivers were allocated to the male age groups.

Table 3-46

1972 INVOLVEMENT RATES BY AGE GROUP

Age	Percent Involvement	Accidents	Male Population 10^3	Involvement per 100,000 Population
		Fatal Accidents		
15-24	65	1,755	19,404	9.04
25-29	15	405	7,482	5.41
30-34	5	135	6,080	2.22
35-44	7	190	11,142	1.71
45-64	8	215	20,345	1.06
		Injury Accidents		
15-24		66,150	19,404	340.9
25-29		14,175	7,482	189.5
30-34		7,560	6,080	124.3
35-44		3,780	11,142	33.9
45-64		2,835	20,345	13.9

The 1972 involvement rates were then applied to the 1985 age structure.

1985 BASELINE AGE MOTORCYCLE INVOLVEMENT PROJECTIONS

Age	Male Population 10^3	Fatal Involvements	Fatal Accidents	Injury Involvements	Injury Accidents
15-24	19,289	9.04	1,745	340.9	65,750
25-29	10,688	5.41	580	189.5	20,250
30-34	9,852	2.22	220	124.3	12,250
35-44	15,409	1.71	260	33.9	5,220
45-64	20,504	1.06	220	13.9	2,850
TOTAL			3,025		106,320

- Accidents, 1985

In making accident projections to 1985, the distinctive pattern of age involvement which characterizes motorcycle accidents is used. The 1972 pattern of involvement is adjusted to account for projected increases in motorcycle usage. A projection was made that there would be approximately 8.5 million motorcycles in use in 1985. This projection was based upon a continuance of historical trends in motorcycle registrations, tempered by a saturation of population within the principal user age groups.

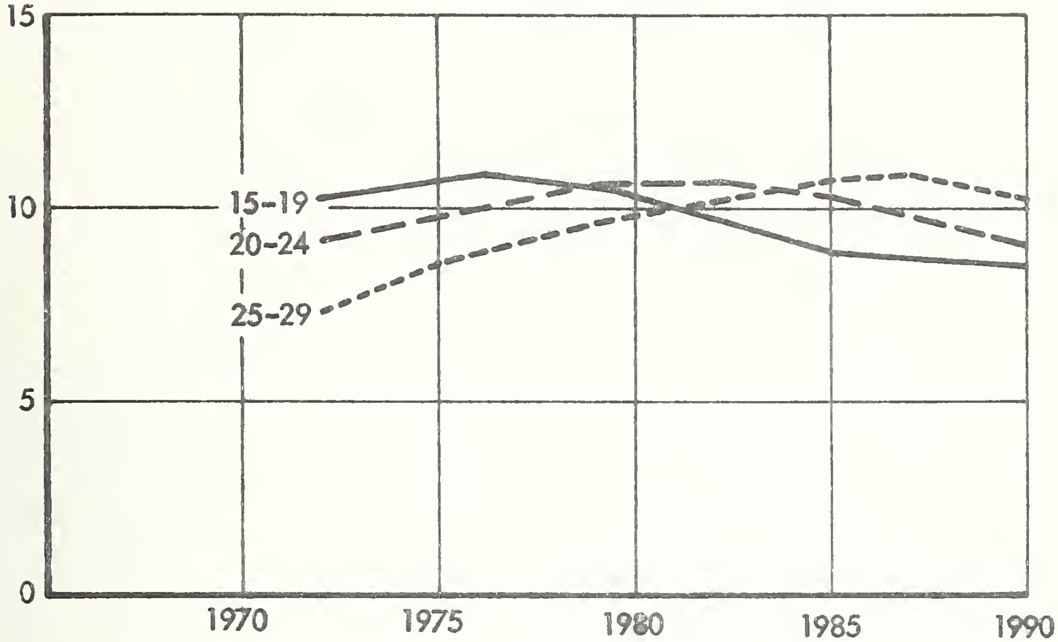
If the 1973 rider death/registered motorcycle ratio is applied to the 1985 projected 8.5 million vehicles, approximately 6,300 fatalities would result in 1985 [(3,310 ÷ 4,222,000) x 8,500,000 = 6,208], an increase of approximately 101% over 1973. If the recent trends in registrations and motorcycle deaths are extended to 1985, an increase of 65% in deaths would result in a 1985 figure of 5,165.

	1968	1973	
Registrations	2,100,000	4,222,000	101% increase in registrations
Deaths	1,900	3,130	65% increase in rider deaths

This is judged to be a realistic "upper bound" for the application of any mitigating factors.

Review of the age groups within male population that accounts for the large proportion of motorcycle accidents reveals that (see Figure 3-34):

- The 15-19 age group peaks out in 1976 and will experience a decline of 12% between 1972-1985.
- The 20-24 age group peaks out in 1982 and will experience an increase of 12% between 1972-1985.
- The 24-29 age group peaks out in 1987 and will experience an increase of 42% between 1972-1985.



U.S. MALE POPULATION (MILLIONS)

Figure 3-34. U.S. Male Population

Thus, the high involvement group, under 25 years, will number approximately the same in 1985 as it did in 1972 while the "safer" age groups, over 25 years, will experience considerable growth. It is also expected that there will be some upward shift in age among motorcycle users because of the economic benefits derived from the low costs of operation.

Practically all studies of motorcycle accidents cite inexperience as a principal causative factor. This factor will be partially ameliorated by the mid-80's for two reasons:

- A large number of the motorcycle operators of the '80's will be from the "dirt bike" generation of the '70's, and will presumably be more competent drivers.
- A growing emphasis upon motorcycle driver training and safety programs.

It is estimated that older, better trained, and more experienced drivers will reduce the fatality rate on the order of 10%. It is also assumed that regulations requiring mandatory helmet usage will be in force nationwide by the mid-80's. It is estimated that such usage would reduce fatalities in the order of another 10%. [35]

5,165 - 20% = 4,132

Therefore, approximately 4,130 fatal accidents involving motorcycle riders will occur in 1985, a 32% increase despite an estimated doubling in number of vehicles. There are no compelling reasons for changing the present fatal/injury accident ratio of 1:35; this results in 144,600 injury accidents.

In summary, 4,130 fatal and 144,600 injury motorcycle accidents will occur in 1985. Of these 2,685 fatal and 94,000 injury accidents will result from collisions with other vehicles, mainly automobiles.

The allocation of 1985 accidents between rural and urban locales, and between day and night, follows the same proportions used for 1972 data (see Table F.1 of Appendix F).

- Motorcycle Speed Data

Examination of motorcycle data contained in the Fatality Analysis File reveals information regarding 838 fatal accidents involving motorcycles and cars. Of the 838 cases, 289 indicate speed of motorcycle and area of impact, and 255 also indicate speed of car; for the majority of cases, no speed information is available. The following percentage figures are based on the reported speed information, the implicit assumption being that the reported sample is representative of the total. Data are available for three accident types listed in Table 3-47.

Table 3-47

	Accident Speeds (%)				
	Under 20	21-40	41-60	Over 60	TOTAL
FRONT OF CAR IMPACTS MOTORCYCLE*					
Motorcycle	21.2	32.8	37.4	8.6	100%
Automobile	27.2	24.7	33.5	14.6	100%
MOTORCYCLE IMPACTS SIDE OF CAR**					
Motorcycle	4.0	38.6	38.6	18.8	100%
Automobile	72.6	15.5	9.5	2.4	100%
MOTORCYCLE IMPACTS REAR OF CAR***					
Motorcycle	7.1	35.7	42.9	14.3	100%
Automobile	92.3	-	7.7	-	100%

*Speed data for 174 motorcycles and 158 cars.
**Speed data for 101 motorcycles and 84 cars.
***Speed data for 14 motorcycles and 13 cars.

The overall type of impact is available for all 838 cases:

	Number	Percent
Total Accidents	838	100
Front of car impacts motorcycle	488	58.2
Motorcycle impacts side of car	303	36.2
Motorcycle impacts rear of car	47	5.6

Injury data from the Fatality Analysis File is not indicative of overall injuries (they report only those injuries associated with accidents in which there were fatalities). The only other motorcycle accident speed data are in Reference 36. Two hundred fifty-two motorcycle injury accidents involving collisions with a second motor vehicle were studied with the following findings.

SPEED OF MOTORCYCLE (MPH) AT TIME OF CRASH

	Under 20	21-40	41-70
Percent	20.2	67.5	12.3

Motorcycle accidents with motor vehicles were estimated by assuming that 65% of the fatal and injury accidents involve another motor vehicle. The resulting frequencies are shown in Table F.1 of Appendix F. Accident occurrences by area of vehicle impact and speed by which motor vehicle was impacted were estimated using the percentage distribution indicated in Table 3-47. The results are shown in Appendix F, Tables F.2 through F.17.

Car-Pedalcycle Accidents

- Accident Data, 1972

NSC indicates that in 1972 pedalcycle accidents resulted in 1,100 fatalities. These were allocated to urban/rural accidents as follows:

Total	1,100
Urban	600
Rural	500

A review of other source data reveals a consistency in that each fatal pedalcycle accident normally results in one fatality. Review of historical data does not reveal any consistent year-to-year trends in the urban/rural proportions for occurrences of this type of accident.

	Urban	Rural
1965	51.5%	48.5%
1966	53.3	46.7
1967	50.0	50.0
1968	52.5	47.5
1969	51.2	48.8
1970	48.8	41.2
1971	52.9	47.1
1972	54.5	45.5

NSC estimates that, in 1972, pedalcycle accidents resulted in 40,000 non-fatal injuries allocated to urban/rural environments as shown below.

NON-FATAL INJURIES

Total	Urban	Rural
40,000	32,000	8,000

Again, because of NSC's exclusion of Category C injuries, other data were analyzed in order to estimate the total number of pedalcycle injury accidents and injuries sustained.

From other sources, pedalcycle fatal/injury accident ratios include"

	FA/IA
New York	1:89.3
California	1:81.3
HSRI	1:113.6

Inasmuch as New York and California together comprise approximately 18% of the nation's population (and that their residents are involved in approximately 18% of the nation's pedalcycle involvements), an average of their fatal accident/injury accident ratios of 1:85 was selected. Application of this ratio to the 1,100 fatal pedalcycle accidents result in 93,500 injury pedalcycle accidents. These are allocated to urban/rural environments in proportion to NSC non-fatal injuries.

Further examination of New York and California data indicates a consistent average of 1.05 injuries sustained for pedalcycle injury accidents. This average was used to determine the following number of injuries.

PEDALCYCLE ACCIDENTS, 1972

Total

FA	1,100	F	1,100
IA	93,500	I	98,000

Urban

FA	600	F	600
IA	74,800	I	78,400

Rural

FA	500	F	500
IA	18,700	I	19,600

Information regarding pedalcycle involvement by day/night was available only from two sources, California and HSRI. The HSRI sample size of seven fatal accidents is not sufficient to provide a realistic representation of fatal involvement. However, their 767 injury accidents do provide considerable insight into pedalcycle accident involvement patterns.

California lists pedalcycle fatal and injury accidents by hour of day of occurrence. By using a year-round interpolation of 7 a.m. - 7 p.m. defining day, their data indicates that 82.2% of fatal and 86.7% of injury accidents occur during those hours.

This compares favorably with HSRI data which indicates that 84.2% of pedalcycle injury accidents occur in day conditions.

The California percentages were used for allocation of fatal and injury accidents to day/night conditions. There is no available information to form a basis for differentiating day and night accident occurrence between urban/rural conditions. A summary of pedalcycle accidents is given in the following table.

PEDALCYCLE ACCIDENTS BY DAY/NIGHT, 1972

Total

FA	1,100	F	1,100
IA	93,500	I	98,000

Urban

FA	600	F	600
IA	74,300	I	78,400

Day

FA	493	F	493
IA	64,850	I	67,970

Night

FA	107	F	107
IA	9,950	I	10,430

Rural

FA	500	F	500
IA	18,700	I	19,600

Day

FA	410	F	410
IA	16,200	I	17,000

Night

FA	90	F	90
IA	2,500	I	2,600

- 1985 Pedalcycle Accidents

As in pedestrian involvement, the pedalcycle accidents are concentrated largely in two age groups and their historical involvement trends can be related to the age structure of the nation's population. To establish a baseline forecast of 1985 pedalcycle accidents, the 1972 involvement ratios by age groups (number of accidents/population in the age groups) were applied to the 1985 population within each age group. The resulting accident figures are shown in Tables 3-48, 3-49, and 3-50. There is growing interest and expanded usage of bicycles. However, this growth has been in the adult age groups which have not been highly involved in accidents. Bicycle safety programs are also receiving greater emphasis, along with expanded use of bikeways and separate bicycle lanes. These features offset, to an unknown degree, the effects of increased bicycle usage.

Table 3-48

PEDALCYCLE DEATHS NUMBER BY AGE GROUP

Year	Under 5	5-14	15-24	25-44	44-64	Over 64	TOTAL
1960	10	350	40	20	20	20	460
1961	10	350	70	20	20	30	500
1962	10	360	50	20	20	40	500
1963	10	370	90	30	30	40	570
1964	20	440	90	50	50	40	690
1965	20	420	120	50	30	40	680
1966	40	500	120	40	20	30	750
1967	20	430	120	40	40	50	700
1968	30	500	120	50	40	60	800
1969	20	530	150	40	40	40	820
1970	20	520	120	70	50	40	820
1971	20	500	200	80	40	20	850
1972	10	540	300	130	80	40	1100

Table 3-49

PEDALCYCLE INJURIES PERCENTAGE BY AGE GROUP

Year	Under 5	5-14	15-24	25-44	44-64	Over 64	TOTAL
1965	3.5	75.0	14.7	2.9	2.1	1.8	
1966	5.4	75.7	13.5	2.4	1.6	1.4	May
1967	3.5	73.5	14.7	3.5	2.9	1.8	not
1968	3.7	75.8	13.2	3.4	2.4	1.6	add
1969	3.3	75.1	14.1	3.6	2.6	1.3	to
1970	3.4	73.7	13.2	5.3	3.2	1.3	100% due
1971	3.3	70.5	15.0	7.5	2.5	1.2	to
1972	3.3	65.5	20.0	7.5	2.5	1.2	rounding.

SOURCE: NSC

Table 3-50

PEDALCYCLE INVOLVEMENT RATES

1 9 7 2

Age	Population (Thousands)	Fatalities	Fatal Involvements per 100,000	Injuries	Injury Involvements per 100,000
Under 5	17,242	10	.06	3,200	18.6
5-14	39,506	540	1.37	64,200	162.5
15-24	38,320	300	.78	19,600	51.1
25-44	50,126	130	.26	7,350	14.7
45-64	42,695	80	.19	2,450	5.7
Over 64	20,949	40	.19	1,200	5.7
TOTAL	208,837	1,100		98,000	

1985 FORECAST

Age	Population (Thousands)	Fatalities	Injuries
Under 5	18,055	10	3,350
5-14	33,517	460	54,450
15-24	38,023	300	19,450
25-44	71,991	190	10,600
45-64	43,402	80	2,450
Over 64	25,924	50	1,500
TOTAL	230,913	1,090	91,800

1972 motor vehicle with pedalcycle accidents were subdivided by collision vehicle weight and vehicle collision area in accordance with injury accident data from Oakland County (see Tables 3-51 and 3-52). The resulting 1972 accident frequencies are shown in Appendix D, Tables D.1 and D.2.

Table 3-51

ADJUSTED* OAKLAND COUNTY PERCENTAGE DISTRIBUTION OF PEDALCYCLE INJURY ACCIDENTS** BY VEHICLE WEIGHT

	Vehicles under 3000 lbs	Vehicles over 3000 lbs
Urban		
Injury Accidents	20.9%	79.1%
Rural		
Injury Accidents	25.8%	74.2%

*See motor vehicle to motor vehicle accident discussion.

**Fatal accident population was judged too small to be representative.

Table 3-52

OAKLAND COUNTY PERCENTAGE DISTRIBUTION OF PEDALCYCLE INJURY ACCIDENTS BY VEHICLE COLLISION AREA

	Vehicles Under 3000 lbs			Vehicles Over 3000 lbs		
	Front	Side	Rear	Front	Side	Rear
Urban						
Injury Accidents	76.7%	10.5%	12.8%	77.1%	15.4%	7.5%
Rural						
Injury Accidents	88.2	7.9	3.9	83.7	12.2	4.1

Because of a scarcity of direct data, it was assumed that the percentage distribution of bracketed collision speeds presented for motor vehicle with pedestrian accidents is suitable for motor vehicle with pedalcycle accidents. The number of accidents for 1972 according to differing speeds are presented in Tables D.3 and D.14 of Appendix D.

The distribution of 1985 accidents by location (urban/rural) and vehicle weight (under 3000 lbs and over 3000 lbs) was achieved by applying the percentage changes between 1972 and 1985 motor vehicle to motor vehicle accidents. The collision speed profiles were assumed to be the same as those used for 1972. The 1985 accident frequencies by location, vehicle weight and impact speed are tabulated in Appendix D, Tables D.15 to D.28.

3.2.4 Summarized Accident Data

Accident Totals. A summary of accident data developed in Section 3.2.3 is presented in Table 3-53. The table lists the accident categories in order of the number of casualty accidents projected for 1985. A casualty accident is an accident which results in either, or both, a fatality or injury (i.e., damage-only accidents are not included).

Table 3-54 shows the relative occurrence of accidents, fatalities, and injuries by accident category. Out of all traffic casualty accidents involving an automobile, vehicle-to-vehicle accidents account for more than 78% of the total. The ratio of registered automobiles weighing less than 3000 lbs to the total number of registered automobiles is approximately 0.3 (see Section 3.1.5). Note in Table 3-54 that for accidents and injuries, all accident categories except vehicle rollover show that the involvement of automobiles under 3000 pounds is slightly less than the registration ratio. However, for vehicle rollover, the involvement ratio of automobiles under 3000 pounds is significantly higher than the registration ratio.

Out of 123.6 million automobiles projected to be operating in 1985, slightly more than 3% will be involved in a casualty accident. This reflects a 3.5% drop from the 1972 involvement rate.

Table 3-53. Accident Summaries for 1972 and 1985

	Casualty Accidents		Fatalities		Injuries	
	1972	1985	1972	1985	1972	1985
Vehicle-Vehicle	2,607,000	3,199,000	24,200	29,700	4,303,000	5,263,000
Vehicle-Fixed Object	340,400	426,800	12,200	15,300	481,000	589,100
Vehicle-Pedestrian	217,800	279,300	10,700	11,800	277,000	283,800
Vehicle-Motorcycle*	(63,200)	(96,700)	(1,800)	(2,700)	(61,400)	(94,000)
Vehicle-Pedalcycle	94,600	88,500	1,100	1,100	98,000	91,800
Rollover	66,700	81,900	4,100	5,100	94,500	115,900
TOTALS	3,326,500	4,075,500	52,300	63,000	5,253,900	6,343,600

*Included in Vehicle-Vehicle Category.

Table 3-54. 1985 Projected Accident Summary

	Casualty Accidents				Fatalities			Injuries		
	Number	% of Total	Accidents Per Auto*	% Involvement Under 3000 lbs	Number	% of Total	% Involvement Under 3000 lbs	Number	% of Total	% Involvement Under 3000 lbs
Vehicle-Vehicle	3,199,000	78.5	.0259	25.3	29,700	47.2	28.7	5,263,000	83.0	25.3
Vehicle-Fixed Object	426,800	10.5	.0035	27.9	15,300	24.3	40.8	589,100	9.3	26.1
Vehicle-Pedestrian	279,300	6.9	.0023	25.3	11,800	18.7	28.6	283,800	4.5	25.2
Vehicle-Motorcycle**	(96,700)		.0008	24.9	(2,700)		24.9	(94,000)		24.9
Vehicle-Pedalcycle	88,500	2.1	.0007	24.9	1,100	1.7	35.8	91,800	1.4	24.9
Rollover	81,900	2.0	.0007	45.0	5,100	8.1	45.0	115,900	1.8	45.0
TOTALS	4,075,500	100.0	.0338	26.0	63,000	100.0	32.7	6,343,600	100.0	25.7

*123,600,000 operating automobiles.

It should be noted that the accident data provided for the 1985 time frame are considered to be baseline projections, i.e., the projections were based on accident statistics and data through 1972 and are unadjusted to reflect any estimates of the potential benefits to be derived from other factors that would influence the baseline projections. Six of these factors are identified in Section 3.4.1, Influence Factors, and estimates of their effects on the baseline projections are presented.

Accident Distribution by Weight, Speed and Direction. Data presented in Appendices A through F are summarized for each accident category to indicate the distribution of casualty accidents, fatalities, and injuries in terms of automobile weight class, impact direction and relative impact velocity.

- Vehicle-Vehicle

Table 3-55 presents the distributions of accident projections for the case where the primary vehicle weighs less than 3000 pounds. The data in the table are summarized from data given in Appendix A (Tables A.17, 18, 19, 23, 24 and 25).

Table 3-56 presents the distributions of accident projections for the case where the primary vehicle weighs more than 3000 pounds. The data in the table are summarized from data given in Appendix A (Tables A.20, 21, 22, 26, 27 and 28).

- Vehicle-Fixed Object

Table 3-57 presents the distributions of accident projections for the case where the vehicle involved weighs less than 3000 pounds. The data in the table include both on- and off-road collisions and are summarized from Appendix C (Tables C.1.65, 66, 67, 71, 72, and 73; Tables C.2.6 through C.2.18 and C.2.31 through C.2.42).

Table 3-55. Vehicle-Vehicle (under 3000 lb) 1985 Projected Accident Summary

		Relative Impact Speed (mph)								TOTAL	
		0-20		20-40		40-60		Over 60			
		Number	%	Number	%	Number	%	Number	%	Number	%
Casualty Accident Vehicles	Front	476,500	29.4	342,000	21.1	111,800	6.9	56,700	3.5	987,000	60.9
	Side	129,700	8.0	64,800	4.0	8,100	0.5	1,600	0.1	204,200	12.6
	Rear	366,300	22.6	58,400	3.6	4,900	0.3	-	-	429,600	26.5
	TOTAL	972,500	60.0	465,200	28.7	124,800	7.7	58,300	3.6	1,620,800	100.0
Fatalities	Front	300	3.5	900	10.3	1,100	12.6	3,900	45.8	6,200	72.2
	Side	700	8.0	500	6.1	400	4.9	200	1.8	1,800	20.8
	Rear	500	5.9	90	1.0	10	0.1	-	-	600	7.0
	TOTAL	1,500	17.4	1,490	17.4	1,510	17.6	4,100	47.6	8,600	100.0
Injuries	Front	393,400	29.5	282,800	21.2	92,000	6.9	42,700	3.2	810,900	60.8
	Side	108,000	8.1	53,300	4.0	6,700	0.5	-	-	168,000	12.6
	Rear	302,800	22.7	48,000	3.6	4,000	0.3	-	-	354,800	26.6
	TOTAL	804,200	60.3	384,100	28.8	102,700	7.7	42,700	3.2	1,333,700	100.0

Table 3-56. Vehicle-Vehicle (over 3000 lb) 1985 Projected Accident Summary

		Relative Impact Speed (mph)								TOTAL	
		0-20		20-40		40-60		Over 60			
		Number	%	Number	%	Number	%	Number	%	Number	%
Casualty Accident Vehicles	Front	1,394,600	29.2	998,200	20.9	329,600	6.9	167,200	3.5	2,889,600	60.5
	Side	367,800	7.7	181,500	3.8	23,900	0.5	-	-	573,200	12.0
	Rear	1,117,600	23.4	181,500	3.8	14,300	0.3	-	-	1,313,400	27.5
	TOTAL	2,880,000	60.3	1,361,200	28.5	367,800	7.7	167,200	3.5	4,776,200	100.0
Fatalities	Front	800	3.7	2,300	10.9	2,800	13.2	10,200	48.2	16,100	76.0
	Side	1,500	7.0	1,100	5.4	900	4.3	300	1.6	3,900	18.3
	Rear	1,000	4.8	200	0.8	20	0.1	-	-	1,220	5.7
	TOTAL	3,300	15.5	3,600	17.1	3,720	17.6	10,500	49.8	21,220	100.0
Injuries	Front	1,151,100	29.3	825,000	21.0	267,200	6.8	121,800	3.1	2,365,100	60.2
	Side	302,600	7.7	149,300	3.8	19,600	0.5	-	-	471,500	12.0
	Rear	931,100	23.7	149,300	3.8	1,200	0.3	-	-	1,092,200	27.8
	TOTAL	2,384,800	60.7	1,123,600	28.6	298,600	7.6	121,800	3.1	3,928,800	100.0

Table 3-57. Vehicle-Fixed Object (under 3000 lb) 1985 Projected Accident Summary

		Relative Impact Speed (mph)								TOTAL	
		0-20		20-40		40-60		Over 60			
		Number	%	Number	%	Number	%	Number	%	Number	%
Casualty Accidents	Front	32,000	26.9	46,300	38.9	16,100	13.5	2,900	2.4	97,200	81.9
	Side	7,900	6.6	5,400	4.5	2,000	1.7	400	0.3	15,600	13.1
	Rear	4,900	4.1	800	0.7	500	0.4	-	-	6,200	5.2
	TOTAL	44,800	37.6	52,500	44.1	18,600	15.6	3,300	2.7	119,000	100.0
Fatalities	Front	200	3.3	1,600	24.9	1,700	27.8	800	12.3	4,300	68.3
	Side	400	6.4	600	9.1	400	6.2	200	2.8	1,600	24.5
	Rear	100	1.8	200	2.5	200	2.9	-	-	500	7.2
	TOTAL	700	11.5	2,400	36.5	2,300	36.9	1,000	15.1	6,400	100.0
Injuries	Front	42,300	27.5	60,600	39.4	20,400	13.3	3,400	2.2	126,700	82.4
	Side	9,800	6.4	6,600	4.3	2,200	1.4	3,100	2.0	18,700	12.3
	Rear	6,500	4.2	1,100	0.7	600	0.4	-	-	8,200	5.3
	TOTAL	58,600	38.1	68,300	44.4	23,200	15.1	3,500	2.4	153,600	100.0

Table 3-58 presents the distributions of accident projections for the case where the vehicle involved weighs more than 3000 pounds. The data in the table includes both on- and off-road collisions and are summarized from Appendix C (Tables C.1.68, 69, 70, 74, 75 and 76; Tables C.2.6, C.2.19 through C.2.30 and C.2.43 through C.2.54).

- Vehicle-Pedestrian

Table 3-59 presents the distribution of accident projections for the case where the vehicle involved weighs less than 3000 pounds. The data in the table are summarized from Appendix B (Tables B.45, 46, 47, 51, 52 and 53).

Table 3-60 presents the distribution of accident projections for the case where the vehicle involved weighs more than 3000 pounds. The data in the table are summarized from Appendix B (Tables B.48, 49, 50, 54, 55 and 56).

- Vehicle-Motorcycle

Table 3-61 presents the distribution of accident projections for the case where the vehicle involved weighs less than 3000 pounds. The data in the table are summarized from Appendix F (Tables F.12 through F.17).

Table 3-62 presents the distribution of accident projections for the case where the vehicle involved weighs more than 3000 pounds. The data in the table are summarized from Appendix F (Tables F.12 through F.17).

- Vehicle-Pedalcycle

Table 3-63 presents the distribution of accident projections for the case where the vehicle involved weighs less than 3000 pounds. The data in the table are summarized from Appendix D (Tables D.17, 18, 19, 23, 24 and 25).

Table 3-58. Vehicle-Fixed Object (over 3000 lb) 1985 Projected Accident Summary

		Relative Impact Speed (mph)								TOTAL	
		0-20		20-40		40-60		Over 60			
		Number	%	Number	%	Number	%	Number	%	Number	%
Casualty Accidents	Front	87,400	28.4	127,400	41.4	44,000	14.3	8,000	2.6	266,800	86.7
	Side	14,500	4.7	8,900	2.9	3,100	1.0	600	0.2	27,100	8.8
	Rear	11,100	3.6	1,800	0.6	900	0.3	-	-	13,800	4.5
	TOTAL	113,000	36.7	138,100	44.9	48,000	15.6	8,600	2.8	307,700	100.0
Fatalities	Front	400	4.2	2,700	30.3	3,100	34.1	1,400	14.9	7,600	83.5
	Side	400	4.2	600	6.2	400	4.2	200	1.9	1,600	16.5
	Rear	-	-	-	-	-	-	-	-	-	-
	TOTAL	800	8.4	3,300	36.5	3,500	38.3	1,600	16.8	9,200	100.0
Injuries	Front	125,400	28.8	179,800	41.3	60,500	13.9	10,000	2.3	375,700	86.3
	Side	20,900	4.8	13,100	3.0	4,400	1.0	8,700	0.2	39,100	9.0
	Rear	16,100	3.7	2,600	0.6	1,700	0.4	-	-	20,400	4.7
	TOTAL	162,400	37.3	195,500	44.9	66,600	15.3	10,700	2.5	435,200	100.0

Table 3-59. Vehicle-Pedestrian (under 3000 lb) 1985 Projected Accident Summary

		Relative Impact Speed (mph)						TOTAL	
		0-20		20-40		Over 40			
		Number	%	Number	%	Number	%	Number	%
Casualty Accidents	Front	35,500	50.3	25,300	35.8	800	1.2	61,600	87.3
	Side	3,500	4.9	2,300	3.3	100	0.1	5,900	8.3
	Rear	3,100	4.4	-	-	-	-	3,100	4.4
	TOTAL	42,100	59.6	27,600	39.1	900	1.3	70,600	100.0
Fatalities	Front	1,300	39.8	1,700	49.4	300	10.2	3,300	99.4
	Side	20	0.6	-	-	-	-	20	0.6
	Rear	-	-	-	-	-	-	-	-
	TOTAL	1,320	40.4	1,700	49.4	300	10.2	3,320	100.0
Injuries	Front	36,200	50.7	25,100	35.1	600	0.9	61,900	86.7
	Side	3,600	5.0	2,600	3.6	100	0.1	6,300	8.7
	Rear	3,300	4.6	-	-	-	-	3,300	4.6
	TOTAL	43,100	60.3	27,700	38.7	700	1.0	71,500	100.0

Table 3-60. Vehicle-Pedestrian (over 3000 lb) 1985 Projected Accident Summary

		Relative Impact Speed (mph)						TOTAL	
		0-20		20-40		Over 40			
		Number	%	Number	%	Number	%	Number	%
Casualty Accidents	Front	103,900	49.8	73,700	35.3	2,500	1.2	180,100	86.3
	Side	9,800	4.7	6,900	3.3	200	0.1	16,900	8.1
	Rear	11,700	5.6	-	-	-	-	11,700	5.6
	TOTAL	125,400	60.1	80,600	38.6	2,700	1.3	208,700	100.0
Fatalities	Front	3,130	37.2	3,890	46.2	800	9.5	7,820	92.9
	Side	50	0.6	70	0.8	20	0.2	140	1.6
	Rear	460	5.5	-	-	-	-	460	5.5
	TOTAL	3,640	43.3	3,960	47.0	820	9.7	8,420	100.0
Injuries	Front	106,600	50.2	73,900	34.8	1,900	0.9	182,400	85.9
	Side	10,600	5.0	7,200	3.4	200	0.1	18,000	8.5
	Rear	11,900	5.6	-	-	-	-	11,900	5.6
	TOTAL	129,100	60.8	81,100	38.2	2,100	1.0	212,300	100.0

Table 3-61. Vehicle-Motorcycle (under 3000 lb) 1985 Projected Accident Summary

		Relative Impact Speed (mph)								TOTAL	
		0-20		20-40		40-60		Over 60			
		Number	%	Number	%	Number	%	Number	%	Number	%
Casualty Accidents	Front	3,800	15.8	3,500	14.4	4,700	19.5	2,000	8.5	14,000	58.2
	Side	300	1.4	3,400	14.0	3,400	14.0	1,600	6.8	8,700	36.2
	Rear	100	0.4	500	2.0	600	2.4	200	0.8	1,400	5.6
	TOTAL	4,200	17.6	7,400	30.4	8,700	35.9	3,800	16.1	24,100	100.0
Fatalities	Front	110	15.8	100	14.4	130	19.5	60	8.5	400	58.2
	Side	10	1.4	90	14.0	90	14.0	50	6.8	240	36.2
	Rear	-	0.4	10	2.0	20	2.4	10	0.8	40	5.6
	TOTAL	120	17.6	200	30.4	240	35.9	120	16.1	680	100.0
Injuries	Front	3,700	15.8	3,400	14.4	4,600	19.5	2,000	8.5	13,700	58.2
	Side	300	1.4	3,300	14.0	3,300	14.0	1,600	6.8	8,500	36.2
	Rear	100	0.4	500	2.0	600	2.4	200	0.8	1,400	5.6
	TOTAL	4,100	17.6	7,200	30.4	8,500	35.9	3,800	16.1	23,600	100.0

Table 3-62. Vehicle-Motorcycle (over 3000 lb) 1985 Projected Accident Summary

		Relative Impact Speed (mph)								TOTAL	
		0-20		20-40		40-60		Over 60			
		Number	%	Number	%	Number	%	Number	%	Number	%
Casualty Accidents	Front	11.500	15.8	10,500	14.4	14,200	19.5	6,200	8.5	42,400	58.2
	Side	1,000	1.4	10,200	14.0	10,200	14.0	4,900	6.8	26,300	36.2
	Rear	300	0.4	1,500	2.0	1,800	2.4	600	0.8	4,200	5.6
	TOTAL	12,800	17.6	22,200	30.4	26,200	35.9	11,700	16.1	72,900	100.0
Fatalities	Front	320	15.8	290	14.4	390	19.5	170	8.5	1,170	58.2
	Side	30	1.4	280	14.0	280	14.0	140	6.8	730	36.2
	Rear	10	0.4	40	2.0	50	2.4	20	0.8	120	5.6
	TOTAL	360	17.5	610	30.4	720	35.9	330	16.1	2,020	100.0
Injuries	Front	11,200	15.8	10,200	14.4	13,800	19.5	6,000	8.5	41,200	58.2
	Side	1,000	1.4	9,900	14.0	9,900	14.0	4,800	6.8	25,600	36.2
	Rear	300	0.4	1,400	2.0	1,700	2.4	600	0.8	4,000	5.6
	TOTAL	12,500	17.6	21,500	30.4	25,400	35.9	11,400	16.1	70,800	100.0

Table 3-63. Vehicle-Pedalcycle (under 3000 lb) 1985 Projected Accident Summary

		Relative Impact Speed (mph)						TOTAL	
		0-20		20-40		Over 40			
		Number	%	Number	%	Number	%	Number	%
Casualty Accidents	Front	10,100	46.0	7,100	32.1	200	0.9	17,400	79.0
	Side	1,300	5.8	900	4.1	20	0.1	2,220	10.0
	Rear	2,400	11.0	-	-	-	-	2,400	11.0
	TOTAL	13,800	62.8	8,000	36.2	220	1.0	22,020	100.0
Fatalities	Front	100	24.6	220	55.1	24	6.2	344	85.9
	Side	10	2.8	10	3.6	3	0.8	23	7.2
	Rear	30	6.9	-	-	-	-	30	6.9
	TOTAL	140	34.3	230	58.7	27	7.0	397	100.0
Injuries	Front	10,600	46.3	7,300	32.0	200	0.8	18,100	79.1
	Side	1,300	5.8	900	4.0	20	0.1	2,220	9.9
	Rear	2,500	11.0	-	-	-	-	2,500	11.0
	TOTAL	14,400	63.1	8,200	36.0	220	0.9	22,820	100.0

Table 3-64 presents the distribution of accident projections for the case where the vehicle involved weighs more than 3000 pounds. The data in the table are summarized from Appendix D (Tables D.20, 21, 22, 26, 27 and 28).

- Rollover

Table 3-65 presents the distribution of accident projections. The data in the table are summarized from Appendix E (Tables E.3 and 4).

Table 3-64. Vehicle-Pedalcycle (over 3000 lb) 1985 Projected Accident Summary

		Relative Impact Speed (mph)						TOTAL	
		0-20		20-40		Over 40			
		Number	%	Number	%	Number	%	Number	%
Casualty Accidents	Front	30,300	45.6	21,100	31.7	600	0.9	52,000	78.2
	Side	5,800	8.7	4,000	6.0	100	0.2	9,900	14.9
	Rear	4,600	6.9	-	-	-	-	4,600	6.9
	TOTAL	40,700	61.2	25,100	37.7	700	1.1	66,500	100.0
Fatalities	Front	220	31.8	280	39.6	60	8.2	560	79.6
	Side	40	5.6	50	7.0	10	1.5	100	14.1
	Rear	40	6.3	-	-	-	-	40	6.3
	TOTAL	300	43.7	330	46.6	70	9.7	700	100.0
Injuries	Front	31,500	45.7	21,900	31.7	600	0.8	54,000	78.2
	Side	6,000	8.7	4,100	6.0	70	0.1	10,170	14.8
	Rear	4,800	7.0	-	-	-	-	4,800	7.0
	TOTAL	42,300	61.4	26,000	37.7	670	0.9	68,970	100.0

Table 3-65. Rollover 1985 Projected Accident Summary

	Speed at Rollover (mph)				TOTAL	
	0-30		Over 30			
Under 3000 lb	Number	%	Number	%	Number	%
Casualty Accidents	1,400	3.7	35,500	96.3	36,900	100.0
Fatalities	90	3.7	2,200	96.3	2,290	100.0
Injuries	1,900	3.7	50,200	96.3	52,100	100.0
Over 3000 lb						
Casualty Accidents	1,700	3.7	43,300	96.3	45,000	100.0
Fatalities	100	3.7	2,700	96.3	2,800	100.0
Injuries	2,400	3.7	61,400	96.3	63,800	100.0

3.3 SOCIETAL COST AND BENEFITS

To assess the levels of safety performance to be specified for the RSV requires an evaluation method based on quantitative measures. The evaluation procedure used in this study is based on measuring the effects of reducing fatalities and injuries in terms of societal costs. The accrued benefits from the RSV will be expressed in terms of the reduction of societal costs based on projected accident data involving standard vehicles (non-RSV's).

Section 3.3.1 establishes the fundamental overall societal costs associated with the 1985 accident environment. The technique and supporting rationale for the benefit-cost analysis, which utilizes societal costs, is presented in Section 3.3.2. The benefit-cost analysis conducted in support of the recommended RSV safety performance specifications is presented in Section 5.7, Volume III.

3.3.1 Societal Costs

The previous sections presented the projected accident environment for the 1985 time frame and the methodology used to obtain those projections. It is of interest now to identify those crash modes with the greatest payoff potential in terms of injury and fatality reduction through the appropriate vehicle design.

To make the desired evaluation requires a method for rating the various accident modes so that a ranking of those accident modes may be made in the order of greatest potential payoff. It is important to note here that "ranking" is merely a first step towards the identification of cost effective, vehicle crashworthiness design solutions, and does not attempt to prove the feasibility of achieving the payoff. This latter effort is the subject matter in Section 5.7, Volume III.

Accident Rating Technique. A method for rating the various vehicle accident modes in terms of payoff potential (potential for reducing injuries and fatalities through proper vehicle design) is desired. The achievement of this desired rating requires a rational measurement standard that may be used as a common reference for judging the relative importance of each accident mode. Societal costs, representing a monetary measurement of the direct out-of-pocket and indirect (i.e., pain and suffering) cost to society from injuries and fatalities resulting from automobile accidents, appears to be a reasonable measurement standard to adopt.

A study by NHTSA determined the approximate societal costs associated with several levels of injury severity ranging from no permanent disability to fatal. Table 3-66 summarizes NHTSA's findings. It was pointed out in the study that the societal costs as derived should be used with discretion since not all of the societal cost contributions reflect "real dollar" values. For the RSV study, societal costs are treated merely as a weighting factor to "weigh" the relative importance of the various projected accident modes. Those modes that incur the highest societal costs are considered to have the greatest safety payoff in terms of future RSV designs that reduce the consequences of the high cost modes. Costs are projected in current dollars to relieve the analyst of contending with uncertain economic variables (inflation rates, taxes, markets, etc.) influencing 1985 costs.

The projected accident data provides three basic characteristics for each crash mode. These are:

- Number of property damage only involvements (over $200)
- Number of injuries (includes Category C injuries*)
- Number of fatalities

---

*Category "C" injuries are: "Complaint of pain without visible signs of injury or momentary unconsciousness".

Table 3-66

Societal Costs for Four Levels of Injury Severity

Component	Fatality	Permanent and Total Disability	Partial Disability	No Permanent Disability
Property damage	$ 1,500	$ 1,000	$ 900	$ 700
Hospital costs	700	5,000	1,600	115
Other medical costs	425	2,800	1,200	200
Funeral costs	900	-	-	-
Legal and court costs	3,000	3,000	1,000	150
Wage losses	132,000	139,000	36,000	200
Miscellaneous accident costs	200	200	100	50
Insurance administration	4,700	4,300	4,300	800
Losses to others	1,300	10,000	1,200	100
Employer losses	1,000	1,000	-	-
Community services	7,000	7,000	1,800	-
Pain and suffering	10,000	50,000	10,000	100
Home and family duties, non-work	33,000	35,000	9,000	50
Assets	5,000	2,000	-	-
Total cost per occurrence	200,725	260,300	67,100	2,465

In this study, the concern is with the vehicle crashworthiness rather than damageability and consequently the last two characteristics listed above are of primary importance here. The societal costs associated with fatalities are comparatively straightforward since only one level of severity exists for this category. The injury category on the other hand ranges in severity from minor (e.g., Category "C" injury) to total disability with a corresponding range in societal costs. NHTSA's study determined an average societal cost \$7,200/incident for the injury category characterizing the 1971 accident environment. This cost reflects an averaged value for all crash modes and velocities and is useful only for top-level comparisons of the various accident modes. For lower level ratings within a given accident mode where considerations for directionality and impact velocity are to be made, new and appropriate averaged societal costs must be determined for the injury category to account for differences in the injury severity distribution.

Developing the Societal Cost Measurement Standard. Two approaches may be taken in developing the societal cost measurement standard. The easiest and most direct approach is to simply use the societal costs for fatality (see Table 3-66) and an overall average injury severity as predicted by NHTSA. This approach however does not account for injury severity distribution and when making comparisons between different accident configurations (e.g., vehicle-vehicle front, rear and side impacts) can lead to erroneous rankings.

A preferred approach is to determine an approximate injury severity distribution for each crash configuration and using the data in Table 3-66, determine an appropriate average societal cost for the injury category. This approach is outlined as follows. Let the societal cost associated with injuries and fatalities resulting from all accidents involving passenger vehicles be defined as,

$$C = \eta \sum_{i=1}^{6} \eta_{"C"_i} \sum_{d=1}^{3} \sum_{V=1}^{4} \overline{CI}^{*}_{i,d,V} \cdot NI_{i,d,V}$$

$$+ \sum_{i=1}^{6} \sum_{d=1}^{3} \sum_{V=1}^{4} \overline{CF}_{i,d,V} \cdot NF_{i,d,V} \qquad (1)$$

where,

C = Total societal cost, all passenger vehicle accidents.

$\overline{CI}*$ = Proxy societal cost, injury category, which must be scaled by $\eta \cdot \eta_{"C"_i}$ to obtain correct societal cost.

$\overline{CF}$ = Average societal cost, fatality category.

NI = Number of injuries (including "C" category injuries).

NF = Number of fatalities.

$\eta_{"C"_i}$ = Scaling factor to remove "C" category injuries in $_i$th crash mode.

η = Scaling factor to satisfy the requirement that the average total societal cost/injury equals $7200 (Reference 50).

Subscripts:

i = Accident Mode

1 = vehicle-vehicle
2 = vehicle-pedestrian impact
3 = vehicle-fixed object
4 = vehicle-non-collision
5 = vehicle-pedalcycle
6 = vehicle-motorcycle

d = Directionality

1 = front
2 = side
3 = rear

V = Velocity

1 = 0-20 mph

2 = 20-40 mph

3 = 40-60 mph

4 = over 60 mph

As pointed out previously, the societal cost associated with fatalities is rather straightforward since only one severity level is involved. The societal costs associated with fatalities may thus be defined explicitly using the NHTSA data (see Table 3-66). Thus,

$$\overline{CF} = \overline{CF}_{i,d,V} = \$200{,}725/\text{incident}$$

Equation 1 may now be simplified to the following form:

$$C = \eta \sum_{i=1}^{6} \text{"}C\text{"}_i \sum_{d=1}^{3} \sum_{V=1}^{4} \overline{CI}^*_{i,d,V} \cdot NI_{i,d,V}$$

$$+ \overline{CF} \cdot NF_{TOT} \qquad (2)$$

where,

$$NF_{TOT} = \sum_{i=1}^{6} \sum_{d=1}^{3} \sum_{V=1}^{4} NF_{i,d,V}$$

As equation 2 suggests, determination of the societal cost, C, associated with passenger vehicle accidents requires the determination of appropriate proxy societal costs associated with injuries, $\overline{CI}^*_{i,d,V}$, which in general are dependent on the accident mode i, directionality d, and impact velocity V. A simplifying assumption however is derived from the following observation. The injury mechanism for vehicle-vehicle and single vehicle fixed object

accident configurations are similar since both involve occupant interaction with the vehicle interior. Likewise, the accident modes involving vehicle-pedestrian, -pedalcycle, -motorcycle can be expected to be similar as a group (but differ significantly from the vehicle-vehicle and single vehicle fixed object accidents) since the common injury mechanism for this group involves the interaction of the victim with the vehicle exterior. It therefore seems reasonable that the societal costs for accident modes within the two groups would have similar dependency on directionality and impact velocity, i.e.:

$$\overline{CI}^*_{1,d,V} \cong \overline{CI}^*_{3,d,V} \tag{3}$$

$$\overline{CI}^*_{2,d,V} \cong \overline{CI}^*_{5,d,V} = \overline{CI}^*_{6,d,V} \tag{4}$$

Note that rollover is not included in this argument; this accident mode is treated separately.

- Societal Costs - Vehicle/Vehicle and Single Vehicle Accidents

Anderson, in his study of vehicle injury sources, uses the tri-level accident investigation program as a data base to derive information regarding injury severity dependency on directionality and impact velocity for vehicle/vehicle and single vehicle accidents. His findings are summarized in Table 3-67. [51]

This data may be used in the following fashion to derive approximate values for the proxy societal costs associated with injuries[1] ($\overline{CI}^*_{i,d,V}$). Let the societal cost for a given injury severity be denoted as $\overline{IC}_j$ (where $j=1 \rightarrow$ no permanent disability; $j=2 \rightarrow$ partial disability; and $j=3 \rightarrow$ permanent and total disability). Using the NHTSA societal costs (see Table 3-66), the following values result:

---

[1]Note, this is a proxy which must be scaled to obtain the correct societal cost.

Table 3-67

Distribution of Injury Severity for Vehicle-Vehicle And Single Vehicle Accidents

Accident Severity	Injury Severity	Frontal Impacts $IN_{1,v,j}$	Rear Impacts $IN_{3,v,j}$	Side Impacts $IN_{2,v,j}$
Minor (0-29 mph)	Minor	1955	363	247
	Non-dangerous	591	99	58
	Dangerous	45	6	11
	Total	2591	468	316
Moderate (30-49 mph)	Minor	3134	371	536
	Non-dangerous	1640	85	257
	Dangerous	276	14	103
	Total	5050	470	896
Severe (over 50 mph)	Minor	1417	95	286
	Non-dangerous	1056	37	195
	Dangerous	493	5	131
	Total	2966	137	612

$$\left.\begin{aligned} \overline{IC}_1 &= \$\ \ 2{,}465 \\ \overline{IC}_2 &= \$\ 67{,}100 \\ \overline{IC}_3 &= \$260{,}300 \end{aligned}\right\} \tag{5}$$

Let $IN_{d,V,j}$ denote the number of injuries with injury severity j for impact direction d and velocity v as determined from the Anderson study (see Table 3-67), then the average societal cost considering directionality and impact speed may be computed from:

$$\overline{CI}^*_{i,d,V} = \left(\sum_{j=1}^{3} \overline{IC}_{d,V,j} \right) / \sum_{j=1}^{3} IN_{d,V,j} \tag{6}$$

where the societal costs $\overline{IC}_j$ are determined from equation 5 and the term $IN_{d,V,j}$ determined from Table 3-67. Recall from equation 3 that,

$$\overline{CI}^*_{1,d,V} \cong \overline{CI}^*_{3,d,V}$$

Thus, using equation 6, the following is obtained:

$$\overline{CI}^*_{1,d,V} \cong \overline{CI}^*_{3,d,V} = \overline{CI}^*_{d,V} = \left(\sum_{j=0}^{4} \overline{IC}_j \cdot IN_{d,V,j} \right) / \sum_{j=0}^{4} IN_{d,V,j} \tag{7}$$

A cautionary comment must be made at this point. The above approach utilizes data from a relatively small data base which may not necessarily be representative of the nation as a whole (for example, some data bases are known to be biased towards the more severe accidents). To account for this, the above averaged societal costs are scaled to give the same overall

averaged societal cost which has been determined to be representative of the nation as a whole (NHTSA computed an averaged societal cost of $7,200/ incident for nationwide injury producing accidents). This scaling effort is conducted as follows:

$$7200 \cdot NI_{TOT} = \eta \sum_{i=1}^{6} \eta_{"C"_i} \sum_{d=1}^{3} \sum_{V=1}^{4} \bar{C}^*_{i,d,V} \cdot NI_{i,d,V} \tag{8}$$

where,

η = scaling factor to be determined, and

$$NT_{TOT} = \sum_{i=1}^{6} \eta_{"C"_i} \; NI_i$$

Thus,

$$\eta = \frac{7200 \cdot NI_{TOT}}{\sum_{i=1}^{6} \eta_{"C"_i} \sum_{d=1}^{3} \sum_{V=1}^{4} \bar{C}^*_{i,d,V} \cdot NI_{i,d,V}} \tag{9}$$

Calculations were made using the above approach and the results are summarized in Table 3-68, and Table 3-69. Table 3-69 shows the variation of average societal costs for front, rear and side impacts and three levels of accident severity. It is noted that the projected data contains four levels of accident severity and consequently, some adjustment to the data on Table 3-69 must be made. It is assumed that the average societal cost determined in Table 3-69 occurs at the mid-point of the respective accident severity range so that the curves in Figure 3-35 may be generated, and new average values estimated for the accident severity ranges (impact speed

Table 3-68

Computing the Societal Costs $\overline{CI}_{d,V,j}$ and $\sum_{j=1}^{5} \overline{CI}_{d,V,j}$

Accident Severity	Injury Severity	Societal Cost/ Injury IC_j	Front Impacts: No. Injuries $IN_{d,V,j}$	Front Impacts: Societal Cost X 10^6	Rear Impacts: No. Injuries $IN_{d,V,j}$	Rear Impacts: Societal Cost X 10^6	Side Impacts: No. Injuries $IN_{d,V,j}$	Side Impacts: Societal Cost X 10^6
Minor (0-29 mph)	Minor	$ 2,465	1955	$ 4.82	363	$ .895	247	$ .61
	Non-dangerous	$ 67,100	591	$ 39.66	99	$ 6.64	58	$ 3.89
	Dangerous	$260,300	45	$ 11.71	6	$ 1.56	11	$ 2.86
	Total		2591	$ 56.19	468	$ 9.10	316	$ 7.36
Moderate (30-49 mph)	Minor	$ 2,465	3134	$ 7.73	371	$ .92	536	$ 1.32
	Non-dangerous	$ 67,100	1640	$110.04	85	$ 5.70	257	$ 17.24
	Dangerous	$260,300	276	$ 71.84	14	$ 3.64	103	$ 26.81
	Total		5050	$189.61	470	$ 10.26	896	$ 45.37
Severe (over 50 mph)	Minor	$ 2,465	1417	$ 3.49	95	$ .23	286	$ .70
	Non-dangerous	$ 67,100	1056	$ 70.86	37	$ 2.48	195	$ 13.08
	Dangerous	$260,300	493	$128.30	5	$ 1.36	131	$ 34.10
	Total		2966	$202.65	137	$ 4.07	612	$ 47.88

Table 3-69

Calculating the Average Societal Cost $\overline{CI}^{*}_{d,V}$

Accident Severity	FRONT IMPACTS			REAR IMPACTS			SIDE IMPACTS		
	Total(1) Injuries	Total(2) Societal Costs X 10^6	(3) Average Societal Cost	Total(1) Injuries	Total(2) Societal Costs X 10^6	(3) Average Societal Costs	Total(1) Injuries	Total(2) Societal Costs X 10^6	(3) Average Societal Costs
Minor (0-29 mph)	2591	\$ 56.19	\$21,690	468	\$ 9.10	\$19,444	316	\$ 7.36	\$23,290
Moderate (30-49 mph)	5050	\$189.61	\$37,550	470	\$ 10.26	\$21,830	896	\$ 45.37	\$50,636
Severe (over 50 mph)	2966	\$202.65	\$68,324	137	\$ 4.07	\$29,708	612	\$ 47.88	\$78,235

(1) Total injuries = $\sum_{j=0}^{4} IN_{d,V,j}$ (from Table 2-3)

(2) Total societal cost = $\sum_{j=0}^{4} \overline{IC}_j \cdot IN_{d,V,j}$ (from Table 2-3)

(3) Average societal cost = $\sum_{j=0}^{4} \overline{IC}_j \cdot IN_{d,V,j} \Big/ \sum_{j=0}^{5} IN_{d,V,j}$ (Equation 6)

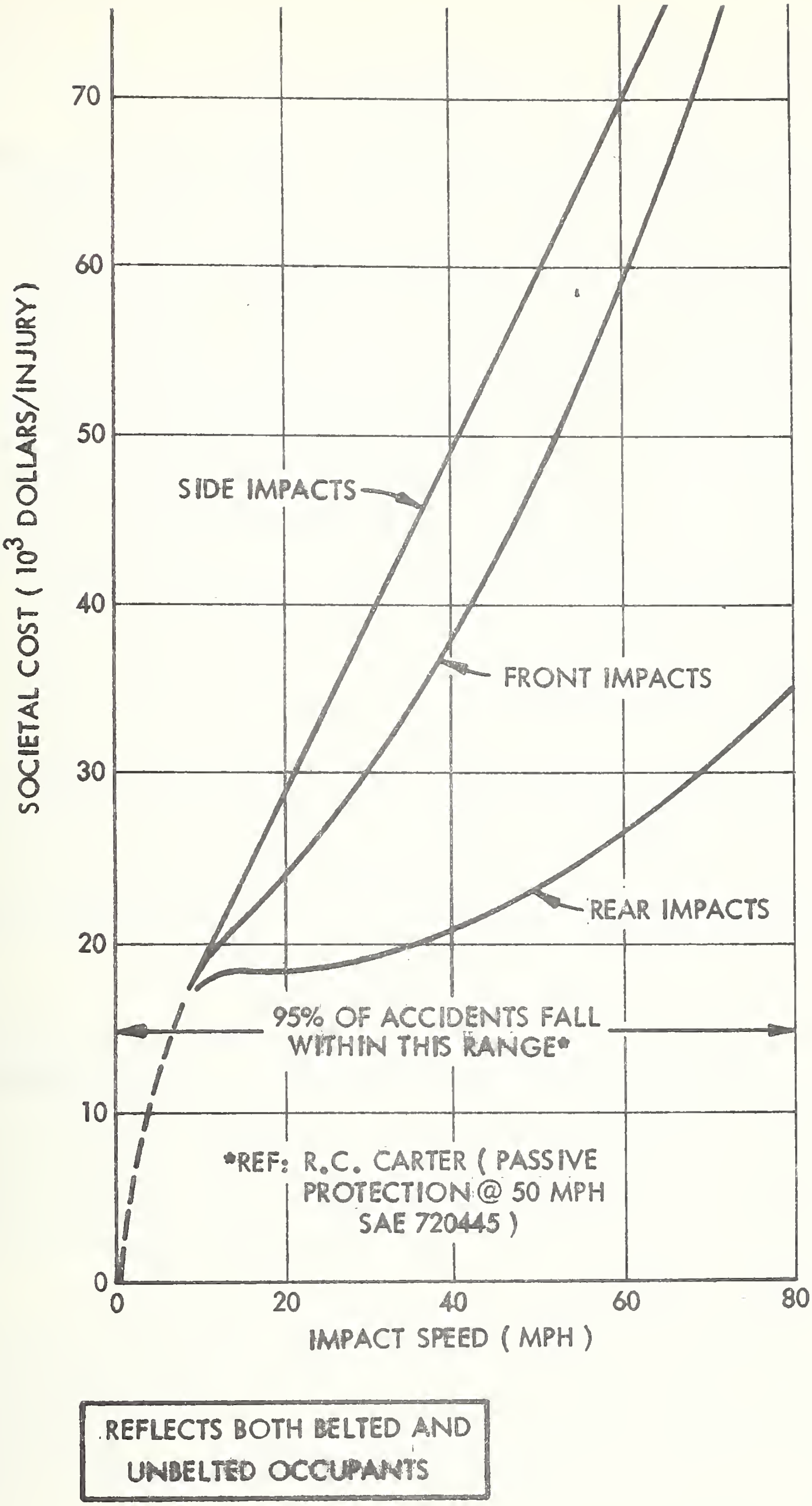


Figure 3-35. Societal Costs vs Relative Impact Speed

ranges) reflected in the projected data. Table 3-70 summarizes the adjusted averaged societal costs that will be used to rate vehicle-vehicle and single vehicle accidents. Note that these values must be adjusted by a scaling factor (see equation 9) to account for the bias in the data base towards higher accident severity.

The preceding analysis was conducted for planar type accidents (i.e., front, side, rear). Rollover type accidents will now be considered. A study by Huelke, et al, provides data which may be used to estimate the [52] average societal cost associated with injuries for vehicle rollover. It will be assumed that injury severity (hence, societal cost) is independent of impact speed, i.e.:

$$\overline{CI}^*_{4,d,V} = \text{constant}$$

As noted previously, the societal cost $\overline{CI}^*$ is a proxy which must be scaled to obtain the actual cost. Table 3-71 summarizes the calculations and results for this study. The resulting averaged societal cost must be scaled by the factor η defined in equation 9 to account for biases towards higher injury severity in the data base.

- Societal Costs - Crash Victim Impacting Vehicle Exterior .

This accident configuration includes all vehicle-pedestrian, -pedalcycle, -motorcycle collisions. As previously noted, this accident group can be expected to have a similar dependency of injury severity (hence, societal cost) on directionality, and speed at impact since all involve interaction of the victim with the vehicle exterior as a major contributor to injuries.

Information required to directly link severity with directionality and speed, for this accident group, is scarce or non-existent, and as a result, data which inferred the relationship was used with engineering analyses. A.J. McLean in the study, "The Man in the Street - Pedestrian [53]

Table 3-70

Summary of Averaged Societal Costs*

for Use in Rating Vehicle-Vehicle and Single Vehicle Accidents

Accident Severity	Front Impacts	Rear Impacts	Side Impacts
0-20 mph	$19,500	$17,500	$ 20,000
21-40	$30,000	$19,500	$ 37,000
41-60	$46,000	$23,900	$ 59,000
Over 60	$72,000	$30,000	$ 80,000

* Note these values must be modified by a scaling factor to account for the bias towards higher accident severity in the data base.

Table 3-71

Calculations for Determining Averaged Societal Cost for Injuries Resulting from Rollover Type Accidents All Speeds

Injury Severity	AIS*	Societal Cost	Percent	Cost/100 ($ x 10^6)
Minor	1	2,465	59.9	.1477
Moderate	2	67,100	12.8	.8589
Severe	3 4	260,300	11.7	3.0455
Fatal	5-9	200,725	15.6	3.131

Averaged Societal Cost:

$$\bar{C}^* = \Sigma C_{injuries}/N_{injuries} = \frac{3.392 \times 10^6}{100-15.6} = \$48,000/\text{Injury}$$

*Ref. [52]

Accidents in the Empire State", provides data showing a direct relationship between vehicle maneuvers, roadway types, and injury severity of pedestrian victims. Tables 3-72 and 3-73 summarize the referenced data. This data infers a relationship between injury severity and impact speed, since each maneuvering action and roadway type is characterized by a speed range within which the vehicle can be driven "comfortably". This "comfort" range may be influenced by the posted speed limit and/or by the handling characteristics of the vehicle. For example, consider a 90° right turning maneuver; it is not conceivable that in a traffic zone with a posted speed limit in excess of 30 mph, this type of maneuver could be accomplished at the posted speed limit "comfortably". For this maneuver then, the probable traveling speed range will correspond to a speed range in which the vehicle handles comfortably. Here, it is assumed that the comfort range is limited to a maximum vehicle acceleration of 0.2 g (both longitudinally and laterally).

The vehicle handling maneuvers considered include the following:

- Right turn
- Left turn
- Straight ahead

The two turning maneuvers will have a maneuvering and speed range which is limited by handling comfort, while the speed associated with the straight-ahead maneuver will be limited primarily by the posted speed limit.

Figure 3-36 illustrates the vehicle handling maneuvers of interest. The limit speed for the right turning maneuver may be computed using the following relationship to compute the centrifugal acceleration of the vehicle:

$$a_c = r \cdot \omega^2 \qquad (10)$$

Table 3-72

Injury Rating by Classification of Road (All Maneuvers)

	Injury Rating, %				Total Number of Cases
	Fatal	Severe	Moderate	Minor	
Limited Access Highways, etc.	11	25	21	43	432
State Highways	9	27	32	32	1,799
County Roads	8	30	35	27	820
Town Roads	3	25	34	38	1,444
Municipal Streets	3	17	23	57	20,847

Total Number of Cases = 26,226

(884 cases occurred off a public road, and the road classification was not recorded in 16 cases.)

Table 3-73

Injury Severity by Action of Striking Vehicle (All Vehicles)

	Injury Rating, %				Total Number of Cases
	Fatal	Severe	Moderate	Minor	
Proceeding straight ahead	4.3	21.5	27.8	46.4	16,688
Turning right	2.2	13.1	23.2	61.5	548
Turning left	2.3	16.1	24.3	57.3	1,241
Reversing	2.5	15.9	26.8	54.8	1,009
Other than the above	1.8	18.1	29.4	50.8	626
Total					20,112

(Cases in which the vehicle action was not known are not listed here.)

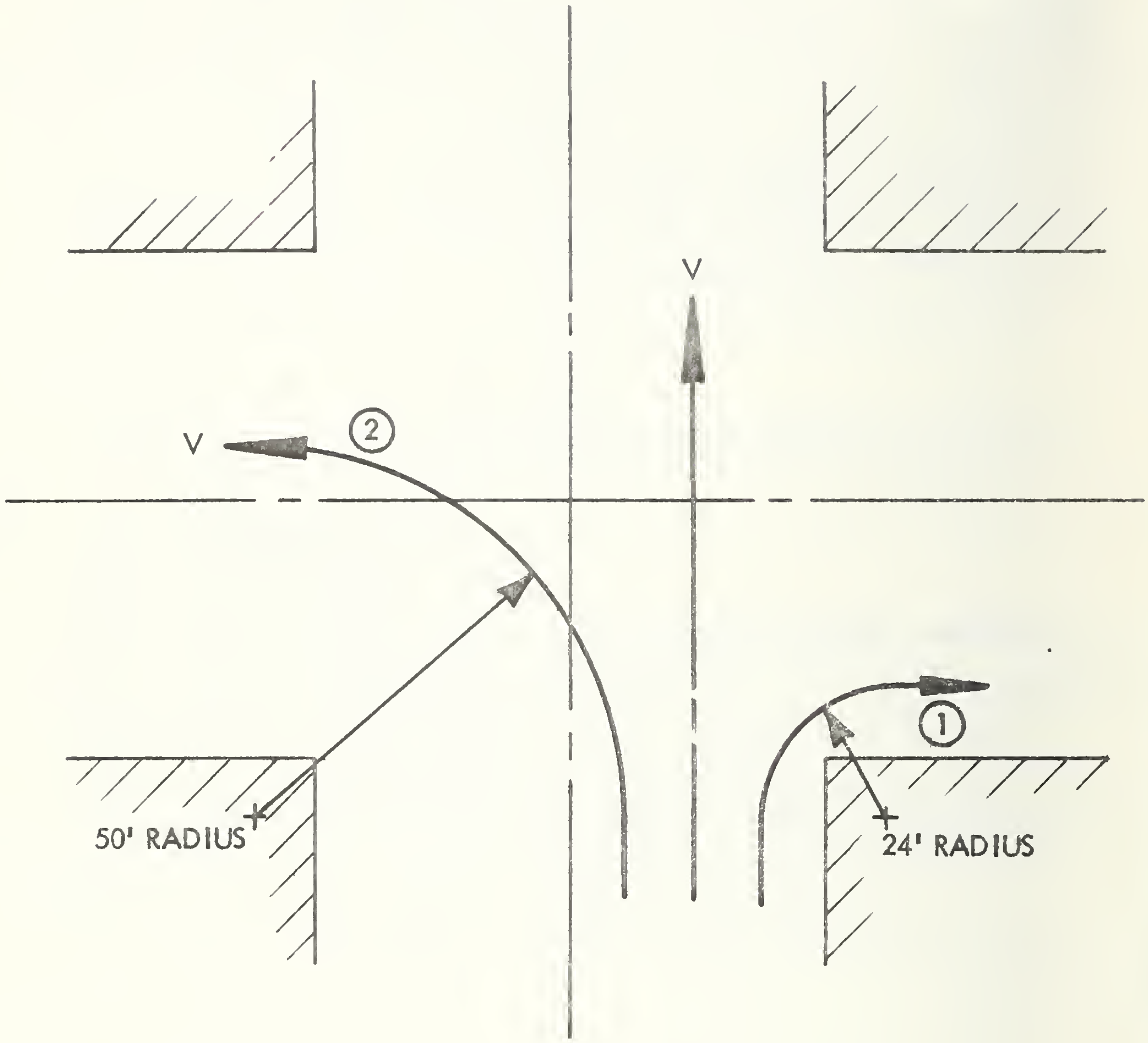


Figure 3 - 36.

Where,

a_c = centrifugal acceleration

r = turning radius of vehicle

ω = angular velocity of vehicle about the center of rotation.

This expression may be reduced to:

$$a_c = \frac{V^2}{r} \tag{11}$$

where V is the traveling speed of vehicle, defined as follows:

$$V = r \cdot \omega \tag{12}$$

Re-arranging equation 11 and solving for V results in

$$V = \sqrt{r\, a_c} \tag{13}$$

Noting that the comfort limit on turning speed is .2 g, then,

$$V_{LIMIT} = 1.73 \sqrt{r} \quad \text{mph}$$

It is assumed that the turning radius for a right and left turning maneuver is 24 and 50 feet respectively, resulting with the following limit speeds:

$$V_{LIMIT/RIGHT} = 1.73 \sqrt{24} = 8.5 \text{ mph}$$

$$V_{LIMIT/LEFT} = 1.73 \sqrt{50} = 12.2 \text{ mph}$$

A speed range of 0-20 mph thus appears to be a reasonable assumption for the speed range associated with a vehicle turning maneuver.

McLean's study shows that the majority of vehicle-pedestrian [53 accidents occurred on municipal streets (20,847 cases out of 26,226). With this in mind, it seems reasonable to assume that the straight-ahead maneuver is characterized by a speed range of 20-40 mph which encompasses the posted speed limits most frequently encountered on municipal streets.

For the higher impact speed range, the following assumptions are made:

Roadway Type	Characteristic Impact Speed Range
Limited Access Highways State Highways	40-60 mph

Table 3-74 summarizes the data that was used to determine proxy societal costs and the dependency of this cost on impact speed.

Table 3-74

Pedestrian Injury Severity vs Impact Speed

Impact Speed	Action of Vehicle	Roadway Type	Injury Rating, % Fatal	Severe	Moderate	Minor
0-20	Turning right	--	2.2	13.1	23.2	61.5
0-20	Turning left	--	2.3	16.1	24.3	57.3
20-40	Straight ahead	Municipal street	4.3	21.5	27.8	46.4
40-60	--	State highway	9	27	32	32
40-60	--	Limited access highway	11	25	21	43
Over 60	Above data extrapolated					

With the assumption that pedestrian impacts are characteristic of other impacts involving the interaction of the crash victim with the vehicle exterior and with the use of the data in Table 3-74, it is now possible to

derive the proxy societal costs $\bar{CI}^*_{i,d,V}$. It is noted that for lack of data it is assumed that the injury severity (and hence, the proxy societal cost) is independent of impact direction, i.e.:

$$\bar{CI}^*_{i,1,V} = \bar{CI}^*_{i,2,V} = \bar{CI}^*_{i,3,V} \qquad i = 2,5,6$$

The values in Tables 3-75, 3-76, and 3-77 were calculated to determine average societal cost for each impact speed range. The top speed range (over 60 mph) was determined by extrapolation as shown in Figure 3-37.

The results of this study are summarized in Table 3-78.

Determining the Payoff Potential for the 1985 Accident Environment. This section evaluates the payoff potential (potential for reducing injuries and fatalities) for the various accident modes in the projected 1985 accident environment. It is important to note that at this time no attempt is made to prove the feasibility of achieving the payoff nor the cost effectiveness of that payoff should it be feasible. This evaluation is limited to identifying those crash modes and crash configurations that appear to have significant payoff potentials.

The societal costs summarized in Tables 3-70, 3-71, and 3-72 were used with the projected 1985 accident data contained in the appendices to determine the ranking of the various crash modes and configurations with regard to total societal cost. The following subsections summarize the results obtained.

- Top Level Accident Mode Considerations

As previously noted, the societal costs determined in Tables 3-70, 3-71 and 3-78 are biased towards high injury severity, reflecting the biases existing in the data base from which these values were derived. To nullify this bias, a scaling factor η (see equation 9) is used to adjust the total societal cost associated with injuries so that the overall average societal cost/injury is \$7200/injury.

Maneuver	Fatal $200,725/Fatality			Severe $260,300/Injury			Moderate $67,000/Injury			Minor $2,465/Injury			TOTALS (Injuries)	
	%	N	Cost $\$10^6$	%	N	Cost $\$10^6$	%	N	Cost $\$10^6$	%	N	Cost $\$10^6$	N	Cost $\$10^6$

Table 3-75. Summary of Calculations for Determining Average Societal Cost Associated with Injuries Resulting from Vehicle-Pedestrian, -Pedalcycle, -Motorcycle Impacts at <u>0-20 mph</u>.

Right Turn	2.2	12		13.1	72		23.2	127		61.5	337		536	
Left Turn	2.3	29		16.1	200		24.3	302		57.3	711		1213	
Average		41	8.23		276	70.8		429	28.79		1048	2.58	1747	10217

Average Societal Cost: $\overline{C} = \Sigma\, C_{injury}/N_{injury}$ = $1[illegible].17 x 10^6/1741 = $58,480/Injury

Table 3-76. Summary of Calculations for Determining Average Societal Cost Associated with Injuries Resulting from Vehicle-Pedestrian, -Pedalcycle, -Motorcycle Impacts at <u>20-40 mph</u>.

Straight-Ahead	4.3	718	144.1	13.1	3588	934.0	23.2	4639	311.3	61.5	7743	19.09	15970	1264.4

Average Societal Cost: $\overline{C} = \Sigma\, C_{injury}/N_{injury}$ = $1264.4 x 10^6/15,970 = $79,172/Injury

Table 3-77. Summary of Calculations for Determining Average Societal Cost Associated with Injuries Resulting from Vehicle-Pedestrian, -Pedalcycle, -Motorcycle Impacts at <u>40-60 mph</u>.

Limited Access Highway	11	48		25	108		21	91		43	186			
State highway	9	162		27	486		32	576		32	576			
Average		210	42.15		594	154.62		667	44.76		762	1.88	2023	201.2

Average Societal Cost: $\overline{C} = \Sigma\, C_{injury}/N_{injury}$ = $201.2 x 10^6/2023 = $99,456/Injury

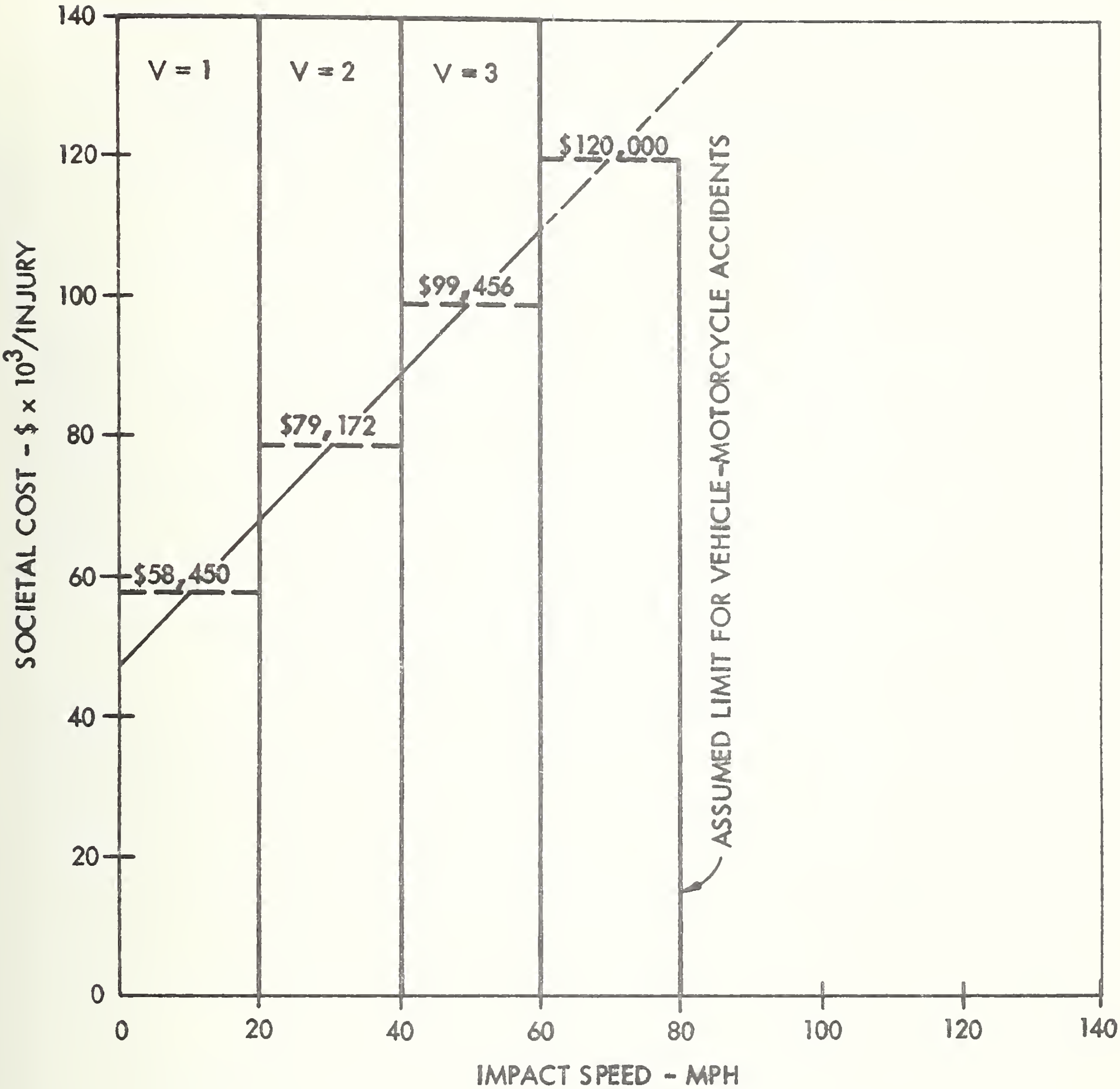


Figure 3-37. Extrapolation Technique for Determining Average Societal Cost for Impact Speeds >60 mph

Table 3-78

Summary of Proxy Societal Costs* for Use in Rating Vehicle-Pedestrian, -Pedalcycle, -Motorcycle Accidents

Impact Speed (Mph)	Societal Cost (%)
0-20	58,480
20-40	79,172
40-60	99,456
Over 60	120,000

*Note: These proxy societal costs values must be modified by a scaling factor to account for the bias towards higher accident severity in the data base (see Eq. 9).

Figure 3-38 shows the societal cost distribution at the top (accident mode, i=1,2,3 ...6) level. It is noted that the societal costs were determined by working "up" the hierarchy chart using equation 1. First, in this calculation procedure, a proxy injury cost was computed, using the following:

$$\overline{CI}^*_i = \sum_d \sum_V \overline{CI}^*_{i,d,V} \; NI_{i,d,V}$$

Where $\overline{CI}^*_{i,d,V}$ represents the unscaled societal cost/injury for impact mode i, direction d, and velocity V, and $NI_{i,d,V}$ represents the total number of injuries (including injury category "C") for impact mode i, direction d and velocity range V. This proxy cost was then scaled by a factor η to determine the true societal cost ($\overline{CI}_i$), i.e.:

$$\overline{CI}_i = \eta_{"C"_i} \cdot \eta \left[\sum_d \sum_V \overline{CI}^*_{i,d,V} \cdot NI_{i,d,V} \right]$$

Note that the factor η was determined from equation 9, which is repeated here for convenience.

$$\eta = \frac{7200 \sum_{i=1}^{6} NI_i \cdot \eta_{"C"_i}}{\sum_{i=1}^{6} \overline{CI}^*_i \cdot \eta_{"C"_i}}$$

The results of the societal cost calculations reveal that the total societal cost associated with all passenger vehicle accidents of interest (projected for 1985) amounts to $38.5 billion (B) with the following distribution and ranking of the various accident modes:

Figure 3-38

PASSENGER VEHICLE ACCIDENTS $\bar{C}$ = \$38.5B (1985)

FATALITIES 65,784

INJURIES $= \Sigma NI_i \cdot \eta_{"C"_i} = 3.514 \times 10^6$

SOCIETAL COST:

FATALITIES	\$13.2B
(INJURIES**	\$191.6B)
INJURIES***	\$25.3B
TOTAL	\$38.5B

$$\eta^2 = \frac{\sum_{i=1}^{6} NI_i \cdot \eta_{"C"_i} (7200)}{\sum_{i=1}^{6} \bar{CI}_i^* \cdot \eta_{"C"_i}} = \frac{(3.514 \times 10^6)(7.2 \times 10^3)}{109.7 \times 10^9}$$

$\eta^2 = 0.2305$

i = 1, $\bar{C}$ = \$21.5B	i = 2, $\bar{C}$ = \$5.60B	i = 3, $\bar{C}$ = \$6.1B	i = 4, $\bar{C}$ = \$2.0B	i = 5, $\bar{C}$ = \$1.2B	i = 6, $\bar{C}$ = \$2.1B
VEHICLE-VEHICLE	VEHICLE-PEDESTRIAN	VEHICLE-FIXED OBJECT (ON/OFF ROAD)	ROLLOVER	VEHICLE-PEDALCYCLE	VEHICLE-MOTORCYCLE
FATALITIES 29,739	FATALITIES 11,994	FATALITIES 15,167	FATALITIES 5,110	FATALITIES 1,090	FATALITIES 2,684
INJURIES* 5,262,500	INJURIES* 288,447	INJURIES* 589,801	INJURIES* 115,927	INJURIES* 91,800	INJURIES 93,990
SOCIETAL COST	SOCIETAL COST	SOCIETAL COST	SOCIETAL COST	SOCIETAL COST	SOCIETAL COST
FATALITIES \$ 5.97B	FATALITIES \$ 2.41B	FATALITIES \$ 3.05B	FATALITIES \$ 1.03B	FATALITIES \$ .22B	FATALITIES \$ .54B
INJURIES** \$134.6B	INJURIES** \$ 19.26B	INJURIES** \$ 17.54B	INJURIES** \$ 5.58B	INJURIES** \$ 6.11B	INJURIES** \$ 8.40B
INJURIES*** \$ 15.51B	INJURIES*** \$ 3.20B	INJURIES*** \$ 3.07B	INJURIES*** \$ .95B	INJURIES*** \$ 1.01B	INJURIES*** \$ 1.54B
SCALING FACTORS	SCALING FACTORS	SCALING FACTORS	SCALING FACTORS	SCALING FACTORS	SCALING FACTORS
$\eta^1_{"C"}$ = 0.5	$\eta^1_{"C"}$ = 0.72	$\eta^1_{"C"}$ = 0.76	$\eta^1_{"C"}$ = 0.74	$\eta^1_{"C"}$ = 0.72	$\eta^1_{"C"}$ = 0.8
η^2 = 0.2305	η^2 = 0.2305	η^2 = 0.2305	η^2 = 0.2305	η^2 = 0.2305	η^2 = 0.2305

(1) Scaling factors determined by GRC to remove "C" category injuries.

(2) Scaling factor (Eq. 9) to determine actual societal costs associated with injuries.

*Includes "C" category injuries.

**Includes "C" category injuries, scaling not performed.

***Excludes "C" category injuries, and is scaled.

		Rank
Vehicle-vehicle	\$21.5B	I
Vehicle-pedestrian	\$ 5.6B	II
Vehicle-fixed object	\$ 6.1B	II
Vehicle-motorcycle	\$ 2.1B	III
Rollover	\$ 2.0B	III
Vehicle-pedalcycle	\$ 1.2B	III

It is apparent from the rankings that vehicle-vehicle impact emerges as the prime contributor to the total societal costs and thus is regarded as the primary impact mode with a significant payoff potential.

- Bottom Level Considerations

By carrying the calculations "down" the hierarchy of accident data, a deeper insight may be obtained into the relationship of impact direction and relative impact speed with societal cost. These calculations are carried out by applying the factors η and $\eta_{"C"_i}$ to the proxy societal cost values $\sum_V \overline{C}^*_{i,d,V} \cdot NI_{i,d,V}$ and $\overline{C}^*_{i,d,V} \cdot NI_{i,d,V}$ previously determined while working "up" the hierarchy of data as described earlier. In effect, the following calculations were performed:

$$\overline{C}_{i,d} = \eta_{"C"_i} \, \eta \sum_V \overline{C}^*_{i,d,V} \cdot NI_{i,d,V}$$

and

$$\overline{C}_{i,d,V} = \eta_{"C"_i} \, \eta \, \overline{C}^*_{i,d,V} \cdot NI_{i,d,V}$$

Where,

$\overline{C}^*_{i,d,V}$ = unscaled societal cost proxy (see Tables 3-70, 3-71, and 3-78).

NI = number of injuries including category "C".

The results of these calculations are shown in Figures 3-39 through 3-44. Table 3-79 summarizes the results.

The results show that for all six impact modes considered, frontal impacts emerge with the greatest payoff potential with regard to reductions in societal cost associated with injuries and fatalities. The results for side vs rear impacts are not as clear-cut, and additional considerations of the relative impact speed will have to be made before a conclusion can be reached. For example, for vehicle-vehicle collisions, the societal costs associated with side and rear impacts are evenly distributed. However, Table 3-79 shows the the 95th percentile speed[1] is 58 mph for side impacts and only 28 mph for rear impacts. Recent ESV specifications require lateral impacts to 40 mph. Should this represent a practical design limit, then from Figure 3-39 it is apparent that for lateral impacts, only 50% of the associated societal cost is available for potential payoff, and the following ranking would result:

Vehicle-Vehicle Accidents

Configuration	Potential Payoff $ Billions	Ranking
Front	15.1	I
Side	(.5) (3.1) = 1.6	III
Rear	3.3	II

Using similar reasoning for the remaining accident modes, the modified ranking listed in Table 3-80 results. Also listed in Table 3-80 are the maximum design impact speeds that were assumed.

---

[1] 95th percentile speed is defined as that relative impact speed encompassing 95% of the associated societal cost.

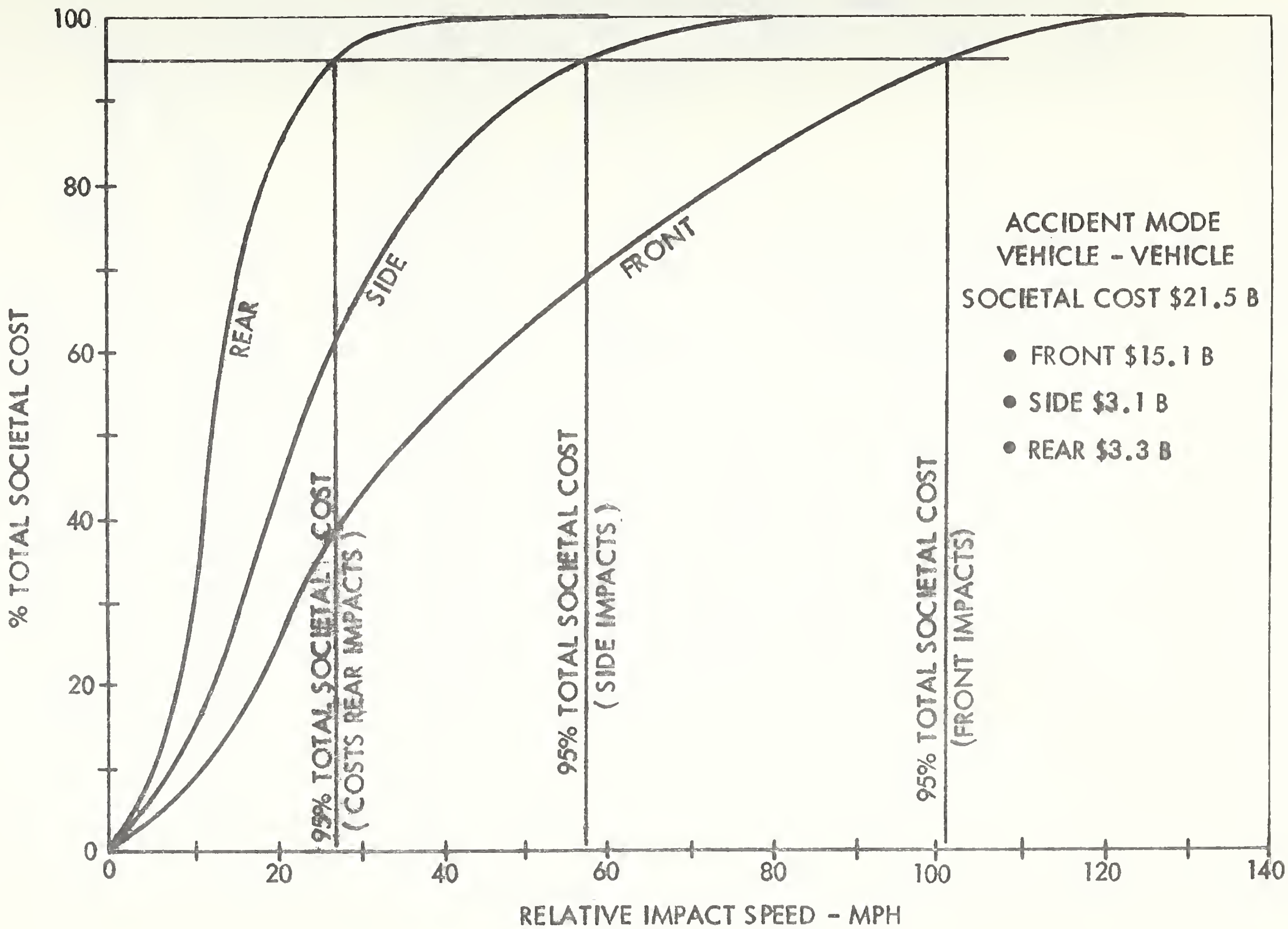


Figure 3 - 39. Societal Cost Distribution - Vehicle- Vehicle Accidents

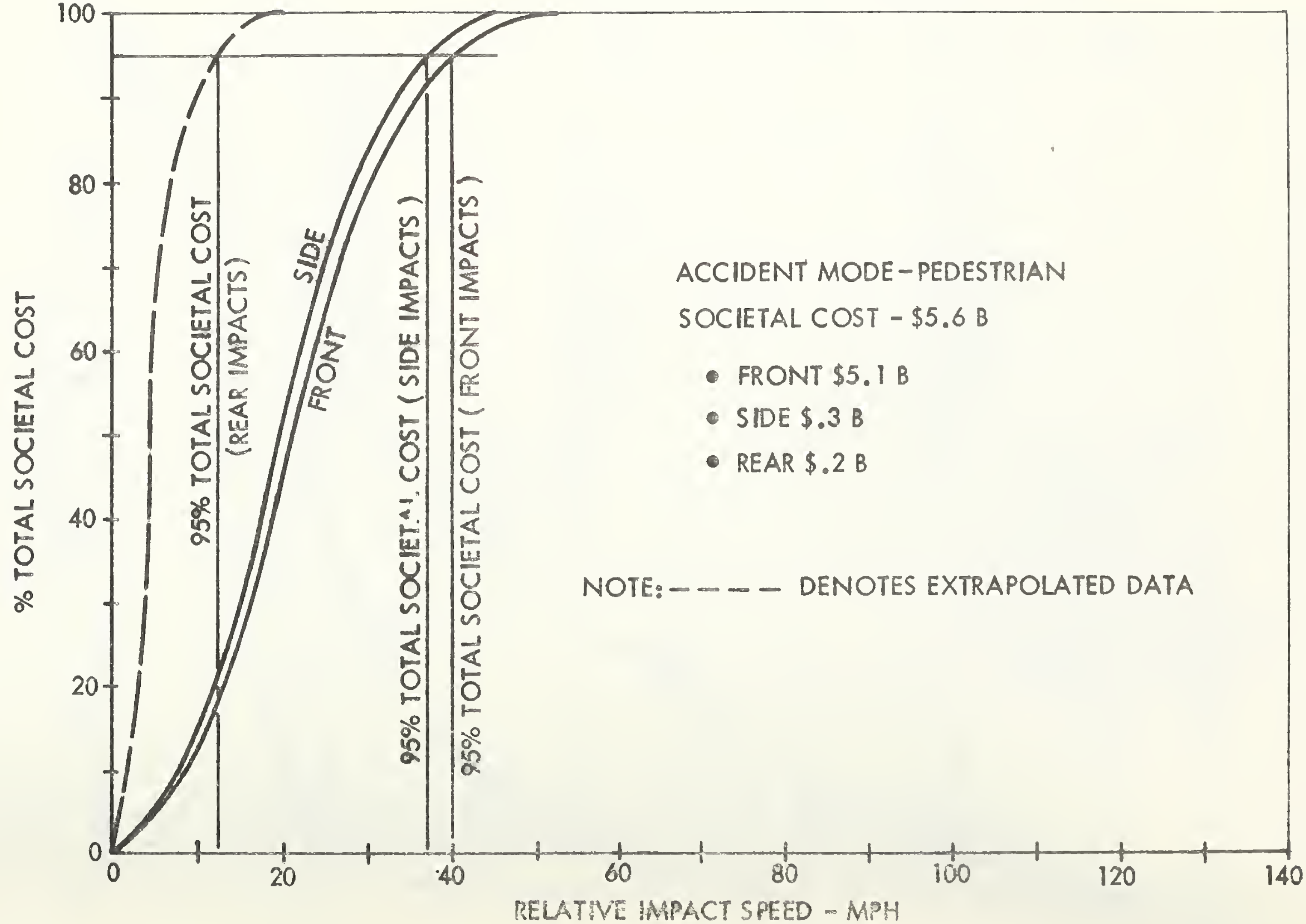


Figure 3-40 Societal Cost Distribution - Vehicle-Pedestrian Accidents

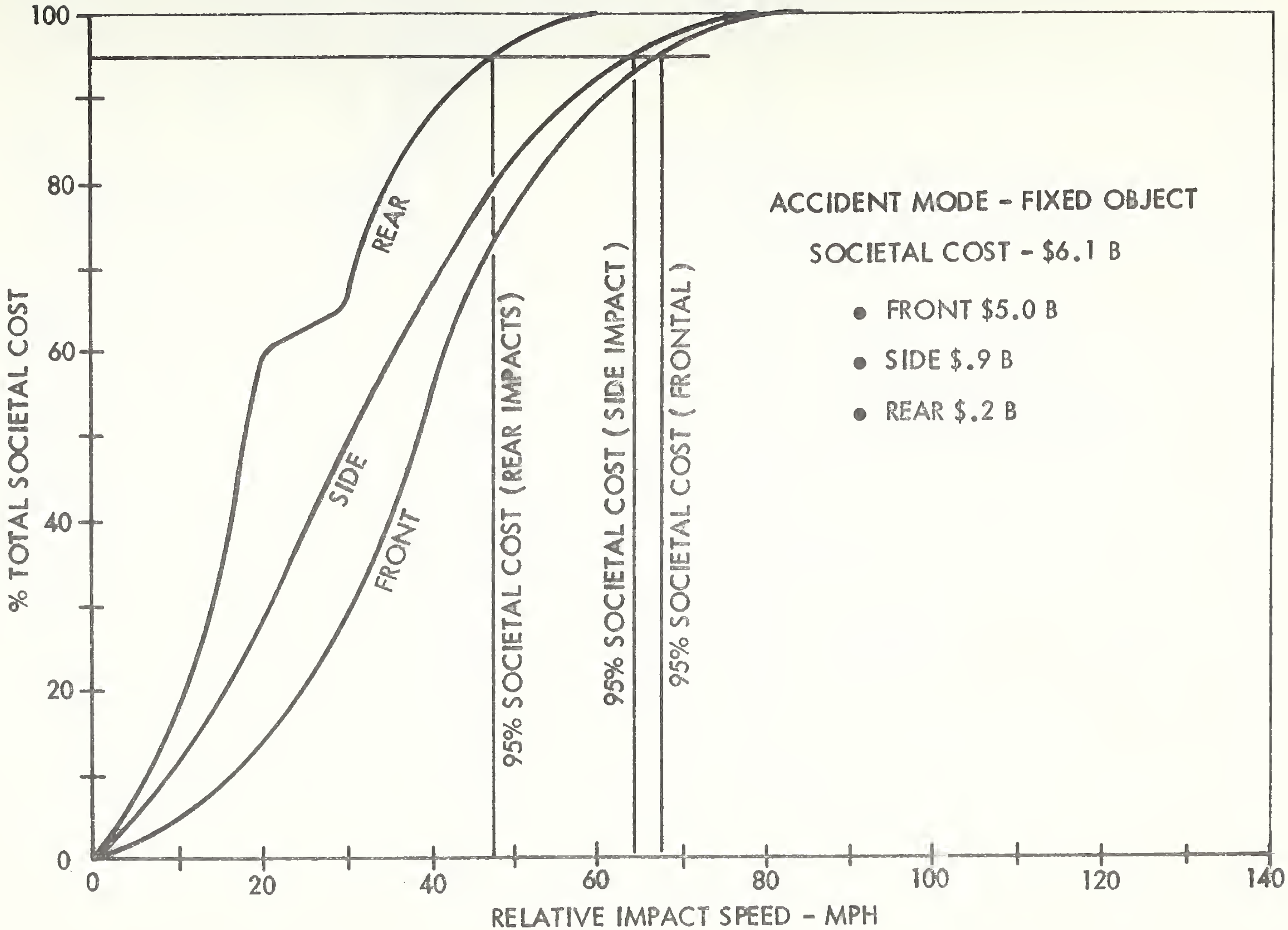


Figure 3-41 Societal Cost Distribution - Vehicle-Fixed Object Accidents

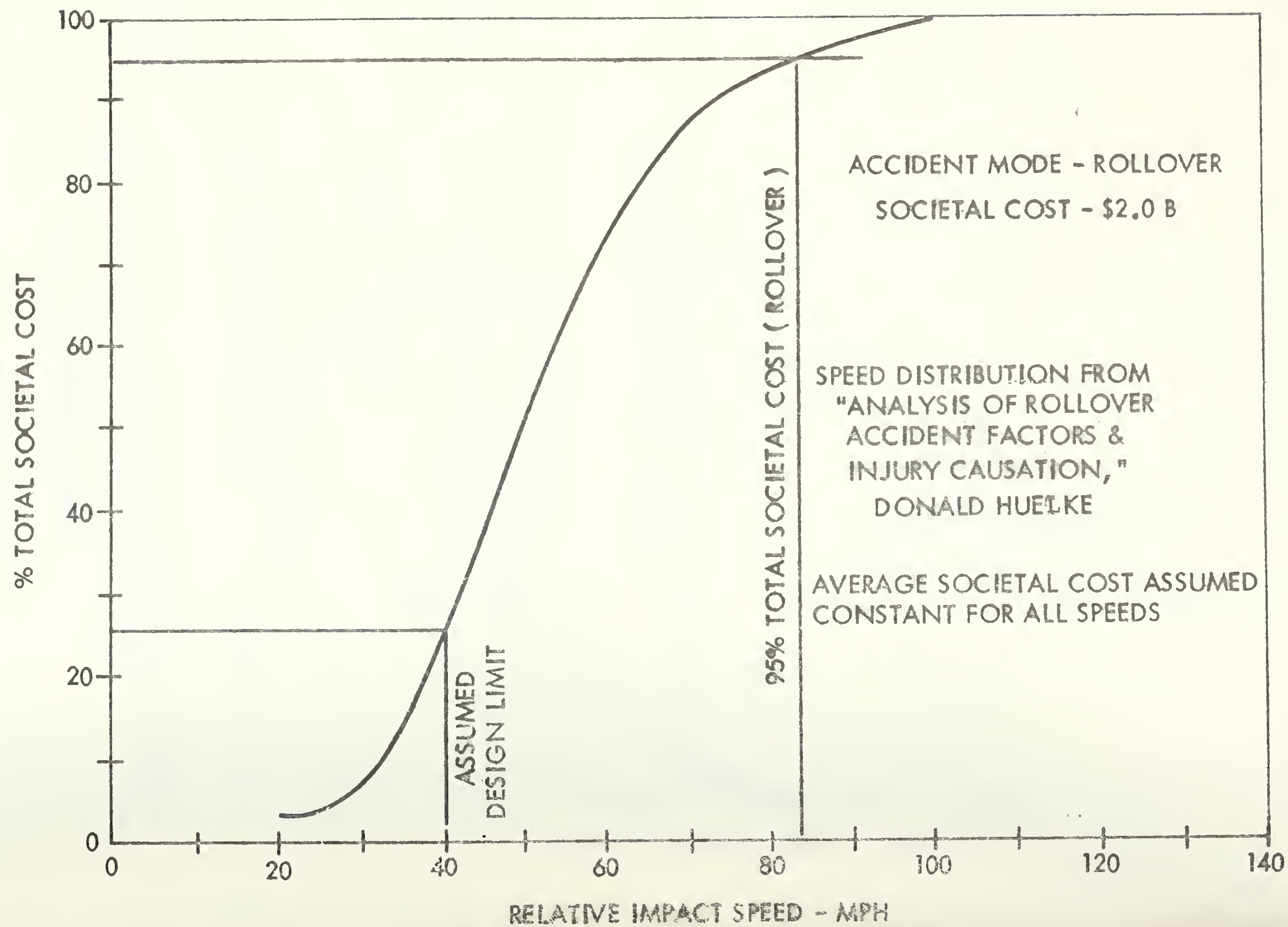


Figure 3 - 42. Societal Cost Distribution - Rollover

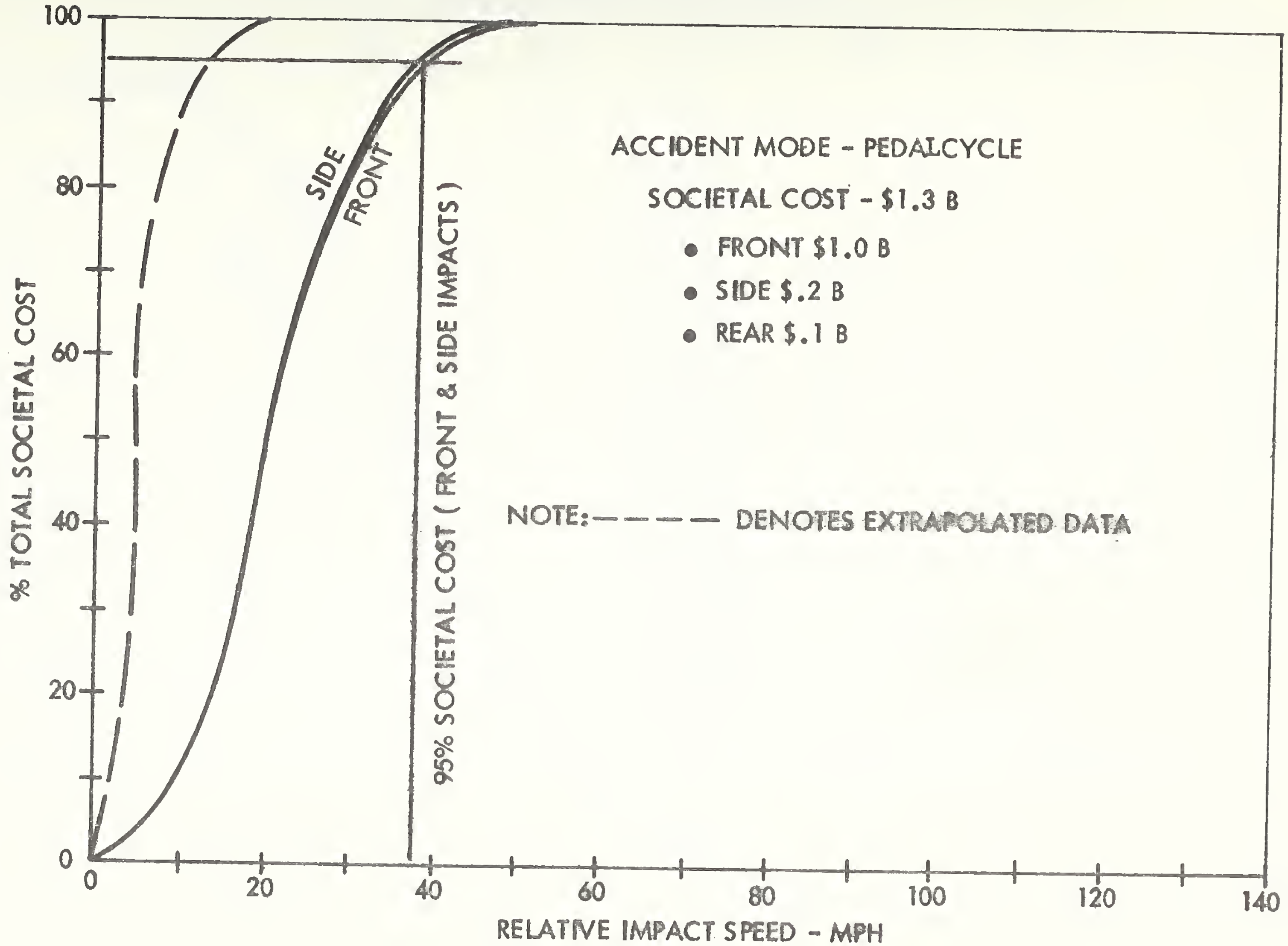


Figure 3 - 43. Societal Cost Distribution - Vehicle-Pedalcycle Accidents

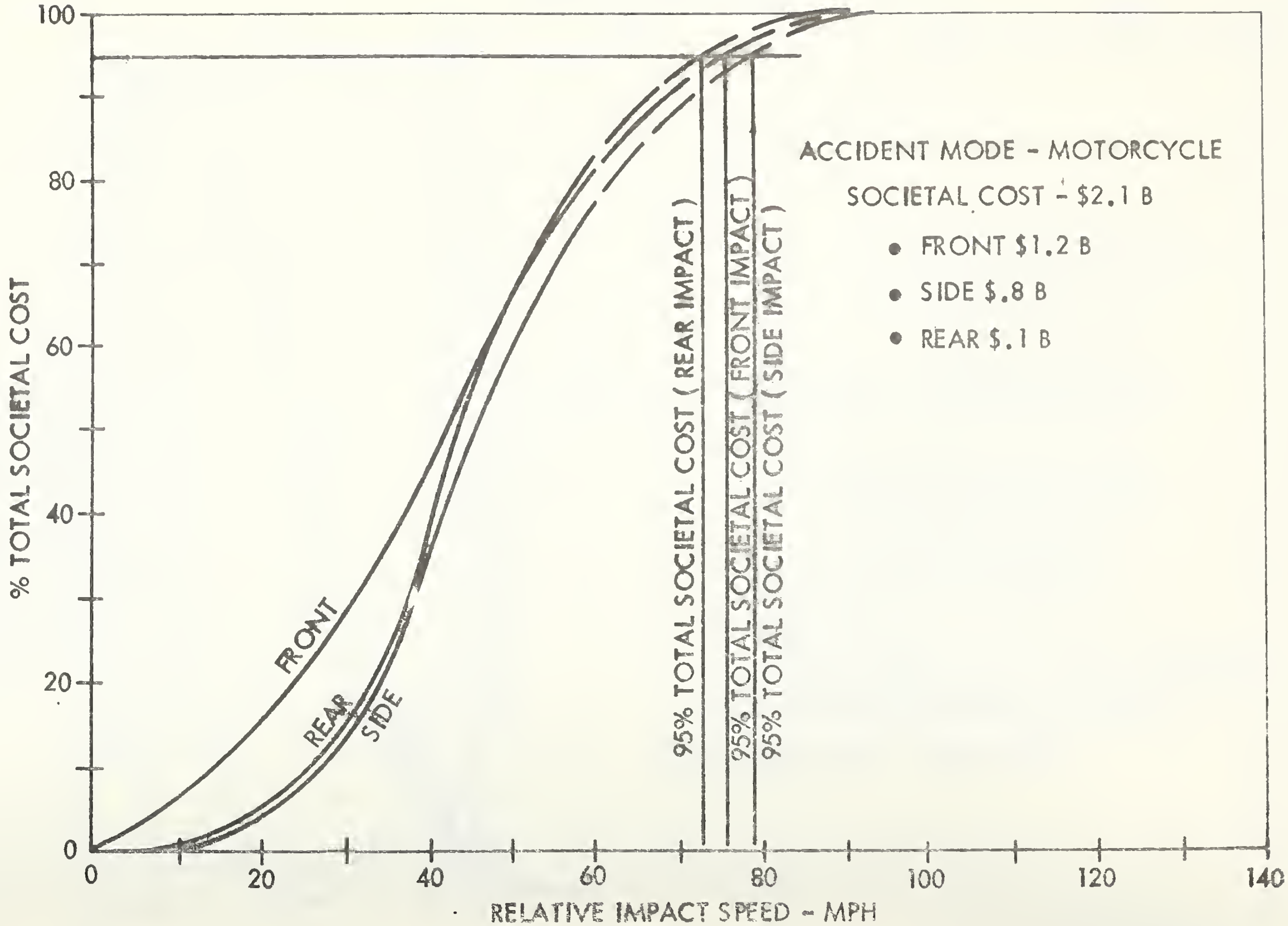


Figure 3 - 44. Societal Cost Distribution - Vehicle - Motorcycle Accidents

Table 3-79

Summary of Results

Impact Direction	Vehicle-Vehicle		Vehicle-Pedestrian		Vehicle-Fixed Object		Rollover		Vehicle-Pedalcycle		Vehicle-Motorcycle	
	Societal Cost $ Billions	95th* Impact Speed, Mph	Societal Cost $ Billions	95th* Impact Speed, Mph	Societal Cost $ Billions	95th* Impact Speed, Mph	Societal Cost $ Billions	95th* Impact Speed, Mph	Societal Cost $ Billions	95th* Impact Speed, Mph	Societal Cost $ Billions	95th* Impact Speed, Mph
Front	15.1	100	5.1	40	5.0	68	-	-	1.0	38	1.2	75
Side	3.1	58	.3	37	.9	64	2.0	83	.2	38	.8	78
Rear	3.3	28	.2	~12	.2	48	-	-	.1	12	.1	72

*95th impact speed is defined as that relative impact speed encompassing 95% of the associated societal cost.

Table 3-80

Summary of Maximum Payoff Potential vs Impact Configuration, Baseline Accident Environment

Impact Direction	Vehicle-Vehicle		Vehicle-Pedestrian		Vehicle-Fixed Object		Rollover		Vehicle-Pedalcycle		Vehicle-Motorcycle	
	Max. Payoff Potential $ Billions	Assumed Impact Speed Design Limit, Mph	Max. Payoff Potential $ Billions	Assumed Impact Speed Design Limit, Mph	Max. Payoff Potential $ Billions	Assumed Impact Speed Design Limit, Mph	Max. Payoff Potential $ Billions	Assumed Impact Speed Design Limit, Mph	Max. Payoff Potential $ Billions	Assumed Impact Speed Design Limit, Mph	Max. Payoff Potential $ Billions	Assumed Impact Speed Design Limit, Mph
Front	15.1	100	2.5	20	3.9	50	-	-	.5	20	.2	20
Side	1.6	40	.2	20	.3	20	.5	40	.1	20	0	20
Rear	3.3	50	.2	20	.2	50	-	-	.1	20	0	20
TOTAL	20.0	-	2.9	-	4.4	-	.5	-	.7	-	.2	-

3.3.2 Benefit-Cost Analysis Techniques

Benefit-cost analysis is a useful process which enables the decision-maker to choose between alternative solutions. In the case of the RSV program, the alternative solutions are represented by various design configurations containing certain design features which enhance the crashworthiness characteristics of the vehicle.

The term "cost", as in benefit-cost, refers to an incurred penalty measured by a specified loss of some tangible value. In this program, some obvious "costs" are increased curb weight, reduction of performance (e.g., acceleration or mileage), and increasing manufacturing or consumer dollar cost. On the other hand, the term "benefit" refers to a measurable gain of some tangible value attributed to the design effort. The "benefits" of interest to the RSV program are reductions in the number of fatalities and injuries, and a reduction in the amount of incurred societal costs.

Care must be taken in establishing a benefit-cost analytical procedure to ensure that adequate fidelity is achieved such that the benefits and costs clearly reflect the safety design features. The benefit-cost relationships for each RSV design configuration considered must all be compatible to allow direct comparisons for the purpose of indicating the most productive approach to safety design.

The approach taken to a benefit-cost analysis for this program consists of evaluating the design effectiveness of an RSV configuration in terms of injuries and fatalities that would result from an accident. In other words, given that an accident occurs, the outcome is expressed by expected-value numbers of injuries and fatalities. These expected values are derived from the baseline accident statistics (Section 3.2) and consider the frequency distributions of accident types, injuries and fatalities in terms of primary impact direction and relative impact velocity.

The purpose of structuring the analysis on a per-accident benefit and cost basis is to circumvent problems associated with an analysis based on total nationwide benefits and costs. Some of the more obvious problems eliminated by this approach are estimating when the RSV specifications would become effective, how many automobiles at a given time period would be operating with the new safety specifications, and how many accidents would involve safety-type cars.

Therefore, the measure of effectiveness is obtained by assessing the average results of an RSV-configured vehicle being in an accident situation and comparing them with the average results of a non-RSV (baseline) vehicle being in an identical accident situation.

A key feature of the approach is that measures of benefits and costs attributable to a given RSV design configuration are computed in terms of incremental increases to, or decreases from, established baseline values.

The baseline condition established for this program represents a typical subcompact automobile weighing approximately 3000 pounds incorporating all contemporary design features of currently produced cars. The current use rate, effectiveness and reliability of standard safety equipment and structure are represented in the baseline condition.

The benefit-cost analysis will be directed to the vehicle-vehicle and vehicle-fixed object accident categories. These two accident categories account for 98% of the casualty accidents, 89% of the fatalities, and 97% of injuries forecast for occupants of motor vehicles in 1985 (see Section 3.2.4, Table 3-54).

Baseline Accident Data. The baseline accident environment for the RSV will consist of the projected data for vehicles weighing less than 3000 pounds for the vehicle-vehicle and vehicle-fixed object accident categories (see Section 3.2.4, Tables 3-55 and 3-57). Using factors established in Reference 58, Tables 3-55 and 3-57 are expanded to reflect a refined apportionment of data to relative impact speed. The refined accident data

is presented in Tables 3-81, 82 and 83 for vehicle-vehicle category and Tables 3-84, 85 and 86 for the vehicle-fixed object accident category.

Baseline Accident Expected Values. On a per-accident basis, expected value numbers are computed for an occupancy factor of 1.9 persons per automobile. That is, the 1.9 persons are apportioned into an expected number of fatalities, injuries and non-injuries given that an accident occurs.

- Vehicle-Vehicle

The number of fatalities expected to occur for the average accident per automobile is:

$$EF = \frac{\text{total number of fatalities}}{\text{total number of vehicles}}$$

$$= 8600/1{,}620{,}800 = 0.005 \text{ fatalities}$$

The expected number of injuries per vehicle is:

$$EI = \frac{\text{total number of injuries}}{\text{total number of vehicles}}$$

$$= 1{,}333{,}700/1{,}620{,}800 = 0.823 \text{ injuries}$$

The expected number of non-injuries per vehicle is:

$$\begin{aligned} EN &= 1.9 - (\text{expected fatalities} + \text{expected injuries}) \\ &= 1.9 - 0.005 - 0.823 \\ &= 1.072 \text{ non-injuries} \end{aligned}$$

<table>
<tr><th rowspan="2">Impact Direction</th><th colspan="12">Relative Speed (mph)</th></tr>
<tr><th>0-20</th><th>20-30</th><th>30-40</th><th>40-50</th><th>50-60</th><th>60-70</th><th>70-80</th><th>80-90</th><th>90-100</th><th>100-110</th><th>110-120</th><th>120-130</th></tr>
<tr><td colspan="13">TABLE 3-81. Vehicle-Vehicle Category, Distribution of Casualty-Accident Vehicles under 3000 lb (%)</td></tr>
<tr><td>Front</td><td>29.4</td><td colspan="2">21.1</td><td colspan="2">6.9</td><td>1.0</td><td>0.7</td><td>0.7</td><td>0.5</td><td>0.4</td><td>-</td><td>0.2</td></tr>
<tr><td>Side</td><td>8.0</td><td colspan="2">4.0</td><td>0.3</td><td>0.2</td><td colspan="7">0.1</td></tr>
<tr><td>Rear</td><td>22.6</td><td>3.3</td><td>0.3</td><td colspan="2">0.3</td><td colspan="7">-</td></tr>
<tr><td colspan="13">Total Number of Vehicles Involved in Casualty Accidents = 1.620,800</td></tr>
<tr><td colspan="13">TABLE 3-82. Vehicle-Vehicle Category, Fatality Distribution for Vehicles under 3000 lb (%)</td></tr>
<tr><td>Front</td><td>3.5</td><td colspan="2">10.3</td><td colspan="2">12.4</td><td>10.1</td><td>6.9</td><td>8.5</td><td>6.9</td><td>9.1</td><td>-</td><td>4.6</td></tr>
<tr><td>Side</td><td>7.8</td><td colspan="2">6.1</td><td>2.5</td><td>2.5</td><td colspan="7">1.8</td></tr>
<tr><td>Rear</td><td>5.9</td><td>0.9</td><td>0.1</td><td colspan="2">0.1</td><td colspan="7">0</td></tr>
<tr><td colspan="13">Total Number of Fatalities = 8600</td></tr>
<tr><td colspan="13">TABLE 3-83. Vehicle-Vehicle Category, Injury Distribution for Vehicles under 3000 lb (%)</td></tr>
<tr><td>Front</td><td>29.6</td><td colspan="2">21.1</td><td colspan="2">6.9</td><td>1.1</td><td>0.7</td><td>0.6</td><td>0.5</td><td>0.2</td><td>0.1</td><td>-</td></tr>
<tr><td>Side</td><td>8.1</td><td colspan="2">4.0</td><td>0.4</td><td>0.1</td><td colspan="7">-</td></tr>
<tr><td>Rear</td><td>22.7</td><td>3.3</td><td>0.3</td><td colspan="2">0.3</td><td colspan="7">0</td></tr>
<tr><td colspan="13">Total Number of Injuries = 1,333,700</td></tr>
<tr><td colspan="13">TABLE 3-84. Vehicle-Fixed Object Category, Casualty Accident Distribution for Vehicles under 3000 lb (%)</td></tr>
<tr><td>Front</td><td>26.9</td><td colspan="2">39.1</td><td colspan="2">13.5</td><td>1.7</td><td>0.4</td><td>0.2</td><td>-</td><td colspan="3"></td></tr>
<tr><td>Side</td><td>6.6</td><td colspan="2">4.5</td><td>1.1</td><td>0.5</td><td>0.3</td><td>0.1</td><td>-</td><td>-</td><td colspan="3"></td></tr>
<tr><td>Rear</td><td>4.1</td><td>0.1</td><td>0.6</td><td>0.2</td><td>0.1</td><td colspan="4">-</td><td colspan="3"></td></tr>
<tr><td colspan="13">Total Number of Casualty Accidents = 119,000</td></tr>
<tr><td colspan="13">TABLE 3-85. Vehicle-Fixed Object Category, Fatality Distribution for Vehicles under 3000 lbs (%)</td></tr>
<tr><td>Front</td><td>3.4</td><td colspan="2">25.1</td><td colspan="2">28.1</td><td>9.4</td><td>1.7</td><td>0.9</td><td>0.4</td><td colspan="3"></td></tr>
<tr><td>Side</td><td>6.4</td><td colspan="2">9.1</td><td>4.3</td><td>1.9</td><td>1.5</td><td>[illegible]</td><td>0.1</td><td>-</td><td colspan="3"></td></tr>
<tr><td>Rear</td><td>1.8</td><td>1.3</td><td>3.3</td><td>0.1</td><td>-</td><td colspan="4">-</td><td colspan="3"></td></tr>
<tr><td colspan="13">Total Number of Fatalities = 6400</td></tr>
<tr><td colspan="13">TABLE 3-86. Vehicle-Fixed Object Category, Injury Distribution for Vehicles under 3000 lb (%)</td></tr>
<tr><td>Front</td><td>27.5</td><td colspan="2">39.4</td><td colspan="2">13.3</td><td>1.5</td><td>0.5</td><td>0.2</td><td>-</td><td colspan="3"></td></tr>
<tr><td>Side</td><td>6.4</td><td colspan="2">4.3</td><td>1.0</td><td>0.4</td><td>0.2</td><td>-</td><td>-</td><td>-</td><td colspan="3"></td></tr>
<tr><td>Rear</td><td>4.2</td><td>0.3</td><td>0.4</td><td>0.1</td><td>0.3</td><td colspan="4">0</td><td colspan="3"></td></tr>
<tr><td colspan="13">Total Number of Injuries = 153,600</td></tr>
</table>

- Vehicle-Fixed Object

In a similar manner, the following expected values are calculated for the vehicle-fixed object accident mode:

EF = 0.054 fatalities

EI = 1.291 injuries

EN = 0.555 non-injuries

Baseline Societal Cost Expected Values. The overall societal costs were derived in Section 3.3.1 and presented in Figure 3-38. The societal cost attributable to vehicles weighing less than 3000 pounds are determined by reducing the values shown in Figure 3-38 by the percent-involvement factors found in Table 3-54. Therefore, the segregated societal costs due to accidents involving vehicles weighing less than 3000 pounds are calculated to be:

$21.5B x 25.3% = $5.44B (vehicle-vehicle category)

and

$6.1B x 27.9% = $1.71B (vehicle-fixed object category)

These societal costs are composed of a fixed cost for each fatality ($200,000) and a variable cost depending on injury severity. For the purpose of the benefit-cost analysis, the following assumptions are made concerning injury societal costs:

1. All occupants suffering nothing worse than slight bruises will be assessed a societal cost of $300 each. These occupants are classified as "non-injured".
2. All occupants with injuries ranging from severe to minor will be assessed an average societal cost which is different for each accident mode (reflecting the severity of the accident

environment, e.g., a vehicle-fixed object accident is a more severe environment than a vehicle-vehicle accident). These occupants are classified as "injured".

- Vehicle-Vehicle

An automobile weighing less than 3000 pounds involved in an accident with another vehicle will result in fatalities and injuries to its occupants producing an average societal cost per accident of:

$$\overline{C} = \$5.44B/1{,}620{,}800 = \$3356 \text{ per vehicle}$$

This amount is composed of the following costs:

$$CF + CN + CI = \$3356$$

where

$$\begin{aligned} CF &= \text{societal cost resulting from fatalities} \\ &= (\text{expected fatalities}) \times \$200{,}000 \\ &= EF\ (200{,}000) \\ &= 0.005\ (200{,}000) = \$1000 \text{ per vehicle} \end{aligned}$$

and

$$\begin{aligned} CN &= \text{societal cost resulting from non-injuries} \\ &= (\text{expected non-injuries}) \times \$300 \\ &= EN\ (300) \\ &= 1.072\ (300) = \$322 \text{ per vehicle} \end{aligned}$$

Finally,

$$CI = \text{societal cost resulting from injuries}$$
$$= \overline{C} - CF - CN$$
$$= 3356 - 1000 - 322 = \$2034 \text{ per vehicle}$$

- Vehicle-Fixed Object

In a similar manner, the values are calculated for the vehicle-fixed object accident.

$$\overline{C} = \$1.71B/119{,}000 = \$14{,}350 \text{ per accident}$$

which is composed of:

$$CF = \$10{,}400$$
$$CN = \$170$$
$$CI = \$3{,}780$$

Maximum Potential Societal Cost Savings Per Accident. If a vehicle could be designed to completely eliminate fatalities and injuries for all impact directions and speeds, the societal cost saved per accident, C_s, would be the average baseline cost per accident less the non-injury cost for all occupants in the vehicle:

$$C_s = \overline{C} - 300\ (1.9)$$

For the vehicle-vehicle accident:

$$C_s = \$2786 \text{ per vehicle}$$

and for the vehicle-fixed object accident, the maximum potential societal cost savings is:

$$C_s = \$13,780 \text{ per accident}$$

The distribution of the maximum potential societal cost saving by the various impact directions and speeds are shown in Tables 3-87 and 3-88.

The cost, C_s, is distributed in the following manner.

$$(C_s)_{D,S} = CF\ (f)_{D,S} + CI\ (i)_{D,S} - CN\ (n)_{D,S}$$

where,

(C_s) is the maximum potential societal cost savings for an accident having an impact direction, D, and a relative impact speed, S.

$(f)_{D,S}$, $(i)_{D,S}$, and $(n)_{D,S}$ are the ratios of fatalities, injuries and non-injuries (occurring at impact direction, D, and relative impact speed, S, to total fatalities, injuries and non-injuries.

Benefits and Associated Costs. The data presented in Tables 3-87 and 3-88 represent the maximum possible improvements that could be achieved by an RSV design over the baseline expected values. Actual improvements affected by realistic design features incorporated by the RSV would be a fraction of the amounts shown in the tables.

An example would be a case where, for the vehicle-vehicle accident category (Table 3-87), the RSV design would be such that fatalities and injuries for frontal impacts are totally eliminated for speeds up to 20 mph and reduced by 50% for the speed range of 20 to 40 mph, with no attainable reductions elsewhere. For this example, the RSV design would offer a benefit of 100% x 20.0% x \$2744 + 50% x 17.0% x \$2744 = \$782 saved per vehicle per accident.

<table>
<tr><th rowspan="2">Impact Direction</th><th colspan="12">Relative Speed (mph)</th></tr>
<tr><th>0-20</th><th>20-30</th><th>30-40</th><th>40-50</th><th>50-60</th><th>60-70</th><th>70-80</th><th>80-90</th><th>90-100</th><th>100-110</th><th>110-120</th><th>120-130</th></tr>
<tr><td colspan="13">TABLE 3-87. Vehicle-Vehicle Category, Distribution of Maximum Potential Societal Cost Savings Per Accident, for Vehicles under 3000 lb (%)</td></tr>
<tr><td>Front</td><td>20.0</td><td colspan="2">17.0</td><td colspan="2">8.9</td><td>4.6</td><td>3.1</td><td>3.5</td><td>2.8</td><td>3.2</td><td>0.1</td><td>1.6</td></tr>
<tr><td>Side</td><td>7.9</td><td colspan="2">5.2</td><td>1.1</td><td>1.0</td><td colspan="7">0.6</td></tr>
<tr><td>Rear</td><td>16.5</td><td>2.5</td><td>0.2</td><td colspan="2">0.2</td><td colspan="7">0</td></tr>
<tr><td colspan="13">Total Potential Societal Cost Savings, C_s, is $2786 per Accident</td></tr>
<tr><td colspan="13">TABLE 3-88. Vehicle-Fixed Object Category, Distribution of Maximum Potential Societal Cost Savings Per Accident, for Vehicles under 3000 lb (%)</td></tr>
<tr><td>Front</td><td>9.6</td><td colspan="2">28.7</td><td colspan="2">24.3</td><td>7.4</td><td>1.3</td><td>0.8</td><td>0.3</td><td rowspan="3" colspan="3"></td></tr>
<tr><td>Side</td><td>6.3</td><td colspan="2">7.8</td><td>3.5</td><td>1.5</td><td>1.2</td><td>0.9</td><td>0.1</td><td>-</td></tr>
<tr><td>Rear</td><td>1.0</td><td>2.6</td><td>0.1</td><td>0.1</td><td></td><td colspan="4">-</td></tr>
<tr><td colspan="13">Total Potential Societal Cost Savings, C_s, is $13,780 per Accident</td></tr>
</table>

In Volume III of this report, the benefits and costs estimates are made in developing the performance specifications for the RSV. The analysis presented in Volume III is based on the technique developed in this section.

The benefit-cost technique is summarized as follows:

- Benefits

  Benefits are derived on a per-accident, per-vehicle basis and represent the improvement offered by the RSV in an accident environment compared with the baseline automobile. Benefits are quantified by calculating the accrued societal costs for the baseline vehicle and RSV and obtaining the cost difference. Hence, the benefit is a measure of incremental improvement.

- Costs

  The cost is the quantified penalty incurred to achieve a given benefit. In order to make the RSV more crashworthy than the baseline vehicle, additional safety features are added resulting in some increase in curb weight. Thus, the cost associated with a particular RSV benefit is represented by either the difference in curb weight between the RSV and baseline vehicle, or the actual dollar cost (to the consumer) of the additional safety features.

3.4 OTHER

3.4.1 Influence Factors

The accident projections presented in Section 3.2 are considered as baseline data which reflect the effect of vehicle safety features, roadway designs, speed limits, driving habits, and other man-environment-vehicle characteristics (in existence prior to, and through, 1972) on current accident patterns. These system factors and characteristics are dynamic and the extent of their changes in the years leading into the mid-80's will influence the baseline projections.

Six specific factors considered as potential change sources are: the national speed limit, the Federal Motor Vehicle Safety Standards (FMVSS), and 4 federal highway safety program standards. Table 3-89 summarizes the factors selected for consideration and the accident category which each factor has the potential of modifying.

Table 3-89. Application of Influence Factors

Accident Category	Speed Limit	MVSS 208	HSPS 3 Motorcycle	HSPS 8 Alcohol	HSPS 12 Highway	HSPS 14 Pedestrian
1. Car-Other Vehicle				X	X	
Frontal	X	X				
Side	X	X				
Rear	X					
2. Non-Collision				X	X	
Overturning	X	X				
Other						
3. Car/Pedestrian				X		X
Frontal						
Side						
Rear						
4. Car/Fixed Object				X	X	
Front	X	X				
Side	X	X				
5. Car/Motorcycle				X		
Frontal	X		X			
Side	X		X			
Rear	X		X			
6. Car/Pedalcycle				X	X	
Frontal						
Side						

These factors were selected because: (1) there is some evidence that their implementation in the United States would modify the accident projections (reduced national speed limit to 55 mph, mandatory helmet usage for motorcyclists, restraint system use, and removal of roadside hazards), or (2) that the accident category incurred societal costs of a sufficiently large magnitude that future effective implementation of the appropriate safety standard (alcohol countermeasures, and pedestrian protection) would be demanded.

In general, each factor can modify an accident projection in one of two ways: (1) by reducing the frequency of occurrence or exposure to, a given accident situation, or (2) by reducing the consequences (trauma) to the persons involved in an accident.

HSP Standard 3, Motorcycle Safety, treats special tests and licenses for motorcycle operation and mandatory helmet usage; therefore, it would influence both accident frequency and accident consequences. While the contribution of each to reducing motorcyclist fatalities is not evident, there has been a general decline in fatality rates since the introduction of this standard. This declining trend was accounted for in the projections of motorcycle accident profiles into 1985. The remaining five factors, not considered in the baseline projections, are the subject of this section.

National Speed Limit. The Emergency Highway Energy Conservation Act, signed into law on January 2, 1974, mandated a national speed limit of 55 mph through June 30, 1975. While the fuel shortage that prompted the act no longer exists, the current inflation control program has energy self-sufficiency in the U.S. and energy conservation as key elements; therefore, extension of the 55 mph limit is anticipated to extend into the mid-80's.

In the first five months of 1974, monthly traffic fatalities showed a decrease ranging from 22% to 25% over the corresponding months in 1973. This reduction is probably the result of other causes (reduced exposure in terms of vehicles on the road and miles driven, reduced driving by the more

accident-prone young drivers) in addition to the lower speed limit. Lacking an analysis of the causal contributions of various elements that make up the current reduction in traffic fatalities, approximations were made of the impact of the 55 mph limit on the baseline projections. In these estimates, a limit figure of 60 mph rather than 55 mph was used. This value is a boundary in one of the speed groupings and drivers, generally, can exceed a speed limit by 5 mph without risking citation. Also, it is assumed that the frequency of occurrence is not changed; but the accidents occur at lower speeds. The succeeding parts of this section present the results of these estimates.

- Vehicle to Vehicle Accidents

  Frontal Impacts

Table 3-90 presents the projected profile for the vehicle to vehicle accidents involving frontal collisions for four speed at impact groups. Since impact speed in these cases is the sum of the speeds of the striking and struck vehicle, the effect of the 55 mph limit will be in the over 60 mph collision group. Some shifts may occur in the 41 to 60 mph profiles, but it is assumed that these shifts will stay within the projected values.

Table 3-90. Projected Vehicle-Vehicle, Frontal Accidents

	0-20	21-40	41-60	Over 60	All
FA	850	2,530	3,080	11,230	17,690
IA	933,850	667,730	216,690	99,710	1,917,980
F	1,070	3,190	3,880	14,170	22,310
I	1,548,400	1,106,460	359,280	165,330	3,179,480
FA*	As	As	3,960	8,010	15,350
IA*	Above	Above	276,790	41,040	1,919,410
F*			4,960	10,100	10,320
I*			459,480	68,130	3,182,470
IA/FA	1,099	264	70	9	
I/F	1,447	347	93	12	
F/FA			1.26	1.26	
I/IA			1.66	1.66	

*Estimated changes due to 55 mph speed limit.

Since the source data from which these projections were derived defined frontal accidents as those where the case vehicle sustained primary damage in its front end, the collision causing the frontal damage could have resulted from head-on, side, or rear impacts. The probable distribution of these impacts, estimated from NSC data, is as follows: 50% [54] head-on, 35% side or angle, and 15% rear in fatal accidents, and 10% head-on, 35% side or angle, and 55% rear in all accidents. With the assumption that the accident distribution is representative of injury accidents, a first approximation of the over 60 mph group distribution frontal accidents by collision type causing the frontal damage is as follows:

	Head-on	Side	Rear	All
FA	5,620	3,930	11,680	11,230
IA	9,970	34,900	54,480	99,710

From one analysis, based on MDAI data, approximately 5% of the [55] head-on collisions involved speed of either or both vehicles in excess of 60 mph, resulting in a relative speed at impact range of 70 to 160 mph. Adherence of all case vehicles to the 55 mph limit would not have resulted in significant shifts from the over 60 mph impact speed group into the 41 to 60 mph group in Table 3-90.

In the side collisions, the assumption is made that impacts are normal and the speed at impact is the speed of the striking vehicle sustaining the frontal damage. Further, if 50% of the accidents occurring above 60 mph are shifted into the 41-60 mph group as a result of the lowered speed limit, the greater than 60 mph group will experience a decrease of 1,970 fatal accidents and 17,450 injury accidents. These accidents will be shifted into the 41-60 mph group where they will be distributed as 270 fatal accidents and 19,150 injury accidents.

In frontal damage sustained as a result of rear end collisions, the assumption is made that 75% of the accidents over 60 mph are shifted into the lower group. This results in a shift of 42,120 accidents from the

greater than 60 mph group into the 41-60 mph group where they will be distributed as 590 fatal accidents and 41,350 injury accidents.

The identifiable shifts, based on the stated assumptions, occur in the side and rear collisions that result in primary frontal damage. The approximated effect of the lower speed limit for frontal accidents is shown in the lower half of Table 3-90. The reduction in fatalities is estimated at approximately 13% while the injuries increase insignificantly.

Side Impacts

The projected accident profile for the vehicle to vehicle side impact collision as a function of impact speed groups is presented in Table 3-91. For this category, the source data identifies side impact accidents as those where the case vehicle incurred primary damage in its side. This is a distinct category from the frontal impacts, treated before, where a side impact caused frontal damage.

It was assumed in this estimate that the impacts are normal and the speed at impact is the speed of the striking vehicle. Further, if 50% of the accidents occurring above 60 mph are shifted into the 41-60 mph group, the profiles for these groups are changed as shown in Table 3-91. On this basis, the estimated decrease in fatalities would be approximately 3%; injuries would increase slightly. These changes are considered insignificant when considered in terms of the probable error inherent in the original data sources.

Rear End Impacts

The rear impact category is defined as one where the case vehicle receives its primary damage in the rear end. In terms of speed limit considerations, this category would not be influenced by the 55 mph law.

Table 3-91

Projected Vehicle-Vehicle, Side Accidents

	Speed at Impact, mph				
	0-20	21-40	41-60	Over 60	All
FA	1,700	1,310	1,050	390	4,450
IA	246,810	122,250	15,430	1,160	385,650
F	2,150	1,660	1,330	500	5,640
I	410,390	202,620	25,570	1,920	640,500
FA*	As	As	1,100	200	4,310
IA*	Above	Above	16,150	580	385,790
F*			1,390	250	5,450
I*			26,770	960	640,740
IS/FA	145	93	15	3	
I/F	191	122	19	4	
F/FA			1.26	1.26	
I/IA			1.66	1.66	

*Estimated changes due to 55 mph speed limit

- Non-Collision Accidents

Rollover

The projected accident profile for this category is presented in Table 3-92. The initial requirements for input data did not anticipate a need for a more detailed breakdown of speeds than that shown in the table. However, an estimate can be made based on a prior detailed MDAI study of rollovers. From that source, in all rollover accidents over 30 mph, the percentage of rollovers in the 31-60 mph group is approximately 70%. On this basis, the projected rollover accident profile for speeds in excess of 60 mph is as follows: [52]

FA = 1,330	F = 1,480
IA = 23,180	I = 33,490

Table 3-92. Projected Rollover Accidents

	Speed Prior to Rollover, mph			
	0-30	Over 30	All	All*
FA	170	4,290	4,460	4,140
IA	2,860	74,580	77,440	71,840
F	190	4,920	5,110	4,740
I	4,290	111,640	115,930	107,560

*Estimated effect of 55 mph speed limit.

In this speed range, as in all others, speed may have been a contributory cause to the rollover, and not necessarily the prime cause. Vehicle malfunctions, tripping, soft road shoulders, steep slopes, etc., induce rollovers. Therefore, it was assumed that 25% of the rollover accidents occurring over 60 mph would be eliminated if the 55 mph limit is observed. The resultant projected profile for this group becomes:

FA = 1,000	F = 1,110
IA = 17,390	I = 25,120

The total estimated reduction of fatalities and injuries in all rollover accidents is approximately 7%.

- Vehicle with Fixed Objects Accidents

The projected accident profiles for vehicle collisions with both on-road and off-road fixed objects in frontal and in side impacts for various impact speed groups are shown in Tables 3-93 and 3-94 respectively. Rear impacts are relatively infrequent, minor in nature, and are not considered.

In fixed object collisions, some prior causal factor (driver inattentiveness or intoxication, loss of vehicle control, vehicle malfunction, etc.) resulted in a deviation from the clear roadway. The role of speed as a prime or contributory cause in these accidents is not clearly identified.

In order to assess the influence of reduced speed limits in these accidents, it is assumed that 50% of the accidents above 60 mph would still occur as a result of human or environmental factors. For the remainder, where the 55 mph speed limit is adhered to, 25% of the accidents would be completely avoided and 25% would still occur but would be shifted into the 41 to 60 mph group.

The results of these approximations are shown in the respective tables for frontal and side impacts with fixed objects. The estimated reduction in fatalities is approximately 7% for frontal impacts and 5% for side impacts. The percentage decrease in injuries in both impact conditions is insignificant.

- Vehicle with Motorcycle Accidents

Projections were made for all motorcycle accidents and for those involving motorcycle collisions with vehicles. The projections for the latter category in terms of speeds at impact are shown in Table 3-95. As noted in Section 3.2.3, very little data exists for vehicle with motorcycle collisions in terms of frequency of involvements, impact speeds, directionality and the severities associated with each set of variables. The

Table 3-93

Projected Vehicle with Fixed Objects, Frontal Collisions
(On-road and Off-road)

	Speed at Impact, mph				
	0-20	21-40	41-60	Over 60	All
FA	510	3,810	4,270	1,870	10,460
IA	114,700	165,260	55,550	9,310	344,820
F	580	4,300	4,820	2,120	11,820
I	167,490	240,930	80,990	13,590	503,000
FA*	As	As	4,470	940	9,730
IA*	Above	Above	58,150	4,660	342,770
F*			5,050	1,060	10,990
I*			84,900	6,800	500,120
IA/FA			13	5	
I/F			17	6	
F/FA			1.13	1.13	
I/IA			1.46	1.46	

*Estimated changes due to 55 mph speed limit.

Table 3-94

Projected Vehicle with Fixed Objects, Side Collisions
(On-road and Off-road)

	Speed at Impact, mph				
	0-20	21-40	41-60	Over 60	All
FA	700	1,000	670	310	2,680
IA	20,940	15,130	4,950	1,020	42,040
F	800	1,140	770	350	3,060
I	30,730	20,730	6,570	1,180	59,210
FA*	As	As	710	160	2,570
IA*	Above	Above	5,250	510	41,830
F*			780	180	2,900
I*			6,830	590	58,880
IA/FA			7	3	
I/F			9	3	
F/FA			1.1	1.1	
I/IA			1.3	1.2	

*Estimated changes due to 55 mph speed limit.

Table 3-95

Projected Vehicle with Motorcycle Accidents

	Speed at Impact, mph				
	0-20	21-40	41-60	Over 60	All
Frontal:					
F	420	390	520	230	1,560
I	14,880	13,510	18,330	7,990	54,710
Side:					
F	40	380	380	180	980
I	1,360	13,130	13,130	6,400	34,020
Rear:					
F	10	50	60	20	140
I	370	1,880	2,260	750	5,260

available data, therefore, precludes making approximations of shifts between impact speed groups as was done in some of the preceding cases. However, the motorcycle and vehicle accident category is analogous to that of the vehicle to vehicle category and it can be inferred that the reduction due to the 55 mph speed limit will be of the same order as was estimated for the vehicle to vehicle category; a 13% reduction in frontal and approximately 3% in side impacts (considered insigificant).

FMVSS 208. At the date of this report, the future requirements of the current and proposed amended versions of FMVSS 208 are uncertain. As a result of Congressional actions, NHTSA is to establish air bag or equally effective passive restraint system requirements after public hearings are held and it is determined that such systems are advisable. Congress still retains the right to veto such standard requirements within 60 days after issuance of the NHTSA standard.

In view of this status, it was decided to defer further consideration of any amended version of FMVSS 208 and its influence on the projected accident profiles until such time as the future requirements of the standard are identified. Then, the appropriate estimates of the benefits of the standards can be conducted, the baseline projections modified, and required revisions made to the specifications and any related preliminary designs. In the interim, the areas of maximum safety payoff potentials in the projected accident environment reflect the effect of FMVSS 208 as it was implemented through 1972, and the need for additional occupant protection in the RSV will be based on those projections and subsequent benefit-cost evaluations.

HSP Standard 8, Alcohol in Relation to Traffic Safety. The published data on the effectiveness of Alcohol Safety Action Projects (ASAP) in reducing DWI accidents is inconclusive. The initial programs involving eight states in a controlled experiment in 1971 provided preliminary data indicating a degree of effectiveness. The ASAP areas, in a nine month

period in 1971, experienced a 9.7% decrease in fatal accidents and an 8.6% decrease in fatalities when compared to the baseline year of 1970. If the national fatality trend followed this ASAP trend, there would have been 4,897 fewer fatalities in the U.S. in 1971. In addition, the estimated benefit-cost ratio in the ASAP areas was 2.8 (cost per death was taken as $200,000). [43]

A later evaluation of ASAP enforcement activity through 1972 indicated that the overall relationship of arrest activity by both the regular and ASAP patrols vs changes in fatal crash data yielded no statistically significant results. The obstacle to establishing a statistical relationship is attributed to a lack of sufficient number of observations in the 29 projects underway. [44]

Unlike other man-oriented standards, the role of alcohol as a causative factor in accidents is well defined; an estimated 20% of pedestrian fatalities and 59% of driver and passenger fatalities are related to drinking drivers. For the purposes of this study, it must be assumed that by the mid-80's, some effective alcohol countermeasure program will be implemented. European experience in countries with widely publicized strict laws and rigid enforcement shows considerably lower drinking driver involvement in fatal accidents (Norway - 15%, Sweden - 10 to 12%, Denmark - 10%). Britain's countermeasure law enacted in 1967 had a significant decrease in fatalities and injuries through 1970, after which that trend was reduced. A recent analysis of this reversal suggests that increased enforcement within the present legislation could counteract this trend. [43,45]

It is not anticipated that DWI involvement rates claimed for the Scandinavian countries will be attained in the U.S. by the mid-80's; however, the magnitude of the problem is such that even a modest reduction as suggested by the earlier ASAP projects should be a feasible goal of this standard. Accordingly, these preliminary values (a 10% decrease in fatal accidents and 9% decrease in fatalities) were used in this study.

Table 3-96 presents the projections of the baseline accident environment and of the baseline environment as modified by the assumed effectiveness of the HSP Standard 8. For this estimate, a uniform 10% reduction in all categories (accidents and severities) was used.

<u>HSP Standard 12, Highway Design, Construction and Maintenance</u>. This standard is concerned not only with the removal, relocation, and redesign of fixed roadside objects, but also with the following, typical safety projects:

- Installation and modification of median barriers, guardrails, and roadside delineation markers.
- Resurfacing to increase skid resistance.
- Signs, lighting, and markings.
- Flattening of side slopes.
- Width and stability of side shoulders.

Therefore, its ultimate influence extends to a greater or lesser extent to all accident categories considered in this study.

While a national inventory of roadside hazards and hazard contribution to various accident categories is not available to estimate the impact of this standard on the major accident categories, there is some evidence that fixed object collisions will be influenced. In a 6-month period in 1972, a statewide study of Pennsylvania accidents showed 357 deaths resulted from cars hitting fixed objects (first object struck) while 290 deaths occurred in car to car crashes and 232 in pedestrian accidents. In an FHWA study of interstate highway systems accidents in the years 1968 through 1971, over half of fatal crashes were the single vehicle, runn off the road type, and in most of these, a fixed object was struck. Another estimate of accidents on a "mythical" mile of a composite interstate highway attributed 26% of all accidents to fixed objects

Table 3-96

Influence of HSP Standard 8 on Baseline 1985 Accident Summaries

	Fatal Accidents		Fatalities		Injury Accidents		Injuries	
	Baseline	HSPS 8	Baseline	HSPS 8	Baseline	HSPS 8	Baseline	HSPS 8
Vehicle to Vehicle	23,500	21,200	29,700	26,700	3,175,000	2,857,500	5,263,500	4,736,800
Fixed Objects (All)	13,300	12,000	15,300	13,800	404,400	364,000	589,100	530,300
Rollover (All)	4,600	4,100	5,100	4,600	77,300	69,600	115,900	104,300
Vehicle to Pedestrian	11,600	10,400	11,800	10,600	267,700	240,900	283,800	255,500
Vehicle to Pedalcycle	1,100	1,000	1,100	1,000	87,400	78,700	91,800	82,600
Vehicle to Motorcycle*	[2,700]	[2,400]	[2,700]	[2,400]	[94,000]	[84,600]	[94,000]	[84,600]
TOTALS	54,100	47,700	63,000	56,700	4,011,800	3,610,700	6,343,600	5,710,500

*Included in Vehicle-Vehicle category.

(except trees) which were inherent in the design of the highway. Based on these indicators, approximations were made of the potential reduction in fixed object collision projections.

Some comparative data are available on the effectiveness of hazard removal projects in reducing accidents and their severity; a summary of this data is as follows:

Source	Fatalities	% Injuries	% Total Accidents [56]
FHWA	25	24	20
Oregon	38	30	27
California	31*	8*	N/A

*California reductions stated in terms of fatal and injury accidents.

For the purpose of estimating the influence of this standard, the FHWA effectiveness figures were used and applied to the on-road fixed object collision category only. This approach is believed to be somewhat conservative because it ignores the off-road events; this conservatism is somewhat offset by the implied assumption that the FHWA data is for on-road fixed objects only.

The projected vehicle accidents with on-road fixed objects in frontal collisions is shown in Table 3-97. The objects included under the cylindrical types are pole, hydrants, and trees. The flat breakaway type can be equally well characterized as yielding objects and typically include guardrails, bridgerails, signs, and fences. The flat rigid objects include abutments, embankments, culverts and ditches. In the "Other" type of fixed objects are the miscellaneous and unidentified objects; there were not considered as subject to any reduction by implementation of the HSP Standard 12.

By applying a 25% reduction factor to both baseline fatality and injury projections for the three identified types of fixed objects, a modified accident profile for frontal impacts with fixed objects is obtained as shown in the lower part of Table 3-97.

Table 3-97

Projected Vehicle Frontal Accidents with Fixed Objects, On-road

	Type of Object				
	Cylindrical	Flat Breakaway	Flat, Rigid	Other	All
FA	1,400	1,400	700	700	4,200
IA	104,300	49,700	23,500	46,500	224,000
F	1,600	1,600	900	900	5,000
I	150,300	71,200	33,700	66,500	321,700
FA*	1,100	1,100	600	700	3,500
IA*	78,300	37,100	17,600	46,500	179,500
F*	1,200	1,200	700	900	4,000
I*	112,700	53,400	25,300	66,500	257,900

*Estimated projections resulting from HSP Standard 12 implementation.

Table 3-98

Projected Vehicle Side Accidents with Fixed Objects, On-road

	Type of Object				
	Cylindrical	Flat Breakaway	Flat, Rigid	Other	All
FA	200	200	200	200	800
IA	9,500	4,300	5,000	6,900	25,700
F	300	200	200	200	900
I	13,800	5,600	7,200	10,100	36,700

The approach taken to approximating the influence of HSP Standard 12 for side impacts with on-road fixed objects was the same as that for frontal impacts. The baseline projections for the side impact category are presented in Table 3-98. The modified projections for all side impacts with fixed objects are as follows:

FA = 600	F = 700
IA = 21,200	I = 30,100

In terms of fatality and injury reductions, the estimated effect of HSP Standard 12 is potentially significant, on the order of 20% for both frontal and side impacts. In terms of potential societal cost benefits, the greatest impact of this standard will be realized in frontal impact events. The rear end events are relatively infrequent and were not considered in this study.

HSP Standard 14, Pedestrian Safety. The problem of reducing pedestrian casualties is similar to that concerned with drinking drivers; both are serious in terms of magnitude and on-going countermeasures projects are not mature enough to demonstrate effective approaches. Again, based on magnitude considerations, it is assumed that some effective pedestrian safety standards will be implemented by the mid-80's, and lacking any other data, a 10% effectiveness was assumed. This assumption would result in an estimated reduction of 1,200 fatalities and 28,300 injuries attributable to this standard.

Summary. The preceding assessments of influence factors resulted in varying degrees of estimated effectiveness. If a 5% reduction in fatalities is taken as a minimum indication of factor influence, then the following accident categories are affected to the degree shown.

Accident Category	Factor: Speed Limit	HSPS #8 Alcohol	HSPS #12 Highway	HSPS #14 Pedestrian
1. Vehicle-Vehicle	13%	10%		
2. Fixed Objects (All)		10%		
Frontal	7%		20%*	
Side	5%		20%*	
3. Rollover	7%	10%		
4. Other		10%		
5. Vehicle-Pedestrian		10%		10%
6. Vehicle-Pedalcycle		10%		
7. Motorcycles (All)	13%**	10%		

*Reduction applicable to on-road events only.

**Reduction applicable to motorcycle to vehicle events only.

Note: Injury reductions are not always the same as those for fatalities; see preceding sections for injury reduction estimates.

The influence factors considered thus far were treated independently; however, they are interrelated and their combined effectivity constitutes an additional influence on baseline projections. To determine an approximation of the combined effect of influence factors on the baseline projections, the preceding reduction percentages were converted into appropriate coefficients and multiplied to obtain an overall coefficient reflecting the modified fatality and injury projections for each affected accident category. Table 3-99 compares the baseline projections and modified projections resulting from combined influence factors.

The overall reductions due to the assumed application of all influence factors are approximately 18% in fatalities and 11% in injuries. This is judged to a be a reasonable though probably conservative trend.

Table 3-99

Projected Baseline and Modified Accident Summaries

Accident Category	Fatalities Baseline	Fatalities Modified	Injuries Baseline	Injuries Modified
1. Vehicle-Vehicle	29,700	23,200	5,263,000	4,736,800
2. Fixed-Objects				
On-road	5,700	3,900	376,300	274,100
Off-road	9,400	9,200	214,000	192,600
3. Rollover	5,100	4,300	115,900	97,400
4. Vehicle-Pedestrian	11,800	9,600	283,800	255,400
5. Vehicle-Pedalcycle	1,100	1,000	91,800	82,600
6. Vehicle-Motorcycle*	[2,700]	[2,200]	[94,000]	[84,600]
TOTALS	63,000	51,200	6,343,600	5,638,900

*Included in Vehicle-Vehicle category.

It is anticipated that full implementation of all current and near-term FMVSS features in the cars of the mid-80's, reduced driving exposures as a consequence of increased driving costs, and increased effectiveness of the HSP Standards could result in attaining reductions in accident severities approaching 25% under the baseline projections.

These forecasts of combined influence factor effectiveness are applied to societal costs associated with the baseline accident projections to determine the resultant changes in payoff priorities.

The societal costs reported in Section 3.3 of this report reflect the baseline accident data projected to the 1985 time frame with no influence factors (e.g., enforcement of improved safety standards, lower speed limits, improved roadway designs, etc.) applied. Average societal costs per injury and fatality for each accident mode were determined (using the data of Figure 3-38) and applied to the results in Table 3-99. These results are summarized in Table 3-100.

Table 3-100

Societal Costs Associated with Modified Accident Summaries

Accident Mode	Baseline Societal Costs $ Billions	Modified Societal Costs $ Billions	% Change
Vehicle-Vehicle	21.5	18.6	-13.4
Pedestrian	5.6	4.5	-19.4
Fixed Object	6.1	5.1	-16.4
Rollover	2.0	1.7	-15.0
Pedalcycle	1.2	1.1	- 8.3
Motorcycle	2.1	1.9	- 9.5
TOTAL	38.5	32.9	-14.5

3.4.2 Secondary Accident Modes

In constructing the current national accident profiles, the available data on the constituent accident modes is concerned primarily with the first collision event. In many accidents, a second event may occur (e.g., vehicle fire after first impact, vehicle striking a fixed object or entering a body of water after running off the road) and the consequences of the second event may be more severe to the vehicle occupants than was the initial one. Some insight into the magnitude of these events is required in order to estimate their comparative societal cost ranking in relation to the primary accident modes and the potential safety payoff that may accrue with the application of appropriate countermeasures.

A related event in this area is the post-crash entrapment of occupants in a vehicle that prevents ingress of rescue personnel or egress of the occupants. This condition may be present as a result of vehicle submergence or or structural damage.

The secondary accident modes are discussed in the subsections that follow, and estimates are presented of their relative magnitudes vis-a-vis the primary accident modes.

Vehicle Submergence. A somewhat conservative estimate is that one percent of all traffic fatalities are the consequences of vehicles enter- [59] ing a body of water. The accumulation of information relevant to the incidence of motor vehicle accidental submergence is essentially non-existent. Using data from submergence studies in the Netherlands - where [59] such accidents are considerably more frequent - one can estimate that the ratio of fatalities to submergence accidents is 0.08.

Based on the above estimates, the 1985 projections would include the following: out of 63,000 traffic fatalities, 630 would be caused by drowning; out of 3,611,000 casualty accidents (excluding pedestrians, pedalcycles and motorcycles), 7,880 would be vehicle submergence accidents.

Fire in Motor Vehicle Accidents. The Cornell Accident Causation [60] and Injury Research Study of 1964 found that fire occurred in 0.45% of all motor vehicle casualty accidents. Based on HSRI data, approximately 1.5% [60] of fatalities of vehicle occupants are a result of fire.

Based on the above estimates, the 1985 projections would include the following: out of 3,611,000 casualty accidents (excluding pedestrians, pedalcycles and motorcycles), 16,200 would result in vehicle fires; out of 47,400 vehicle occupant fatalities, 710 would be caused by fire.

The incidence of vehicle fires and resultant fatalities, therefore, is estimated to be quite low. The probability of a vehicle fire occurring due to a casualty traffic accident is 0.45%. Given that a casualty accident accompanied by fire occurs, the probability that the accident would result in a fatality due to the fire is 4.4%.

In quantifying the relative importance of the vehicle fire accident mode, societal costs were determined only for fatalities. There is no data source to estimate injuries received exclusively as a result of vehicle fires (i.e., no differentiation between injuries due to fire and injuries caused by the accident dynamics prior to the fire). Table 3-101 indicates that the societal cost due to fatalities resulting from the vehicle fire accident mode is $0.142. This amounts to only 0.48% of the total societal cost attributed to vehicle occupants killed or injured in accidents.

If one were to make the very conservative assumption that in addition to the 710 fatalities caused by the fire, there are 21,000 injuries resulting exclusively from fire, the vehicle fire accident mode would then account for 1% of the total societal costs. Therefore, if fire were completely eliminated in vehicle accidents, the total societal cost reduction would be on the order of only 1/2 - 1%.

Post-Crash Entrapment. This event affects two areas: occupant escape to avoid fire, drowning or an imminent chance of a secondary

The incidence of vehicle submergence and resultant fatalities, therefore, is estimated to be quite low. The probability of a vehicle submergence accident occurring is 0.2%. Given that a vehicle submergence accident occurs, the probability that the accident would result in a fatality is 8%.

The relative importance of the vehicle submergence accident mode is quantified by computing its contribution to the total societal costs incurred by vehicle occupants either killed or injured (see Table 3-101). The societal cost due to vehicle submergence fatalities is $0.126 billion. As indicated in Table 3-101, if fatalities caused by vehicle submergence were completely eliminated, the total societal cost would show an insignificant reduction of only 0.43%.

Table 3-101

1985 Projections for Vehicle Submergence and Fire Accident Modes

Accident Mode	Casualty Accidents		Fatalities		Societal Cost	
	Number	Percent	Number	Percent	$\$ \times 10^9$	Percent
Submergence	7,880	0.22	630	1.33	0.126	0.43
Fire	16,200	0.45	710	1.50	0.142	0.48
All Other*	3,586,920	99.33	46,060	97.17	29.332	99.09
TOTAL*	3,611,000	100.0	47,400	100.0	29.6	100.0

*Includes the vehicle-vehicle, -fixed object, and rollover accident categories. Excludes the vehicle-pedestrian, -motorcycle, and -pedalcycle accident categories.

collision; and <u>rescue operations</u> to minimize further injury aggravation during rescue (handling victim during extraction and time to extract).

No data exists which shows the correlation of accident casualties with occupant entrapment. Available data does not indicate, for example, that a fatality due to drowning or fire occurred as a result of the victim being entrapped and unable to escape, or as a result that escape was possible but the victim was unable to escape because of unconsciousness or an immobilizing injury.

Also lacking is data showing how the injury severity level is significantly increased due to rescue extraction difficulties and length of rescue time as affected by the degree of entrapment.

Until sufficient data becomes available, there is no quantitative method to assess post-crash entrapment and thus derive specific design requirements that would minimize this event.

References - Section 3

1. U.S. Bureau of the Census, "Current Population Reports," Series P-25, U.S. Government Printing Office, Washington, D.C.

2. U.S. Bureau of the Census, "Historical Statistics of the United States, Colonial Times to 1957," Washington, D.C.

3. U.S. Bureau of Census, "Statistical Abstract of the U.S., 1973," (94th Edition), Washington, D.C.

4. Reference 3, No. 493, "Projections of the Population of the United States, by Age and Sex: 1972 to 2020".

5. U.S. Department of Transportation, "Nationwide Personal Transportation Study," Report No. 6, "Characteristics of Licensed Drivers", Washington, D.C., April 1973.

6. Department of Transportation, Federal Highway Administration, "1972 National Highway Needs Study," House Document No. 92-266, U.S. Government Printing Office, Washington, D.C., March 1972.

7. U.S. Department of Transportation, "Highway Statistics," various reports, U.S. Government Printing Office, Washington, D.C. (printed annually).

8. Reference 1, No. 258.

9. "The National Energy Dilemma, Displayed for Total Viewing," J. Bridges, The Conference Board Record, August 1973.

10. "The Energy Outlook for Transportation in the United States", M.E. Campbell, Traffic Quarterly, April 1973.

11. "The Energy Crisis: Alternatives for Transportation", Automotive Engineering, March 1973.

12. "1972 Automobile Facts and Figures", Motor Vehicle Manufacturers Association, Inc., Detroit, Michigan, 1973.

13. "Economic Report of the President", U.S. Government Printing Office, Washington, D.C., February 1974.

14. U.S. Department of Transportation, 1972 National Transportation Report, "Present Status - Future Alternatives", July 1972.

15. U.S. Department of Transportation, "Highway Statistics - Summary to 1965", 1970.

16. "1970-71 Transit Fact Book", American Transit Association, 1971.

17. J.D. Wells, et al, "Economic Characteristics of the Urban Transportation Industry", U.S. Department of Transportation, February 1972.

18. "1973-1974 Transit Fact Book", American Transit Association, 1974.

19. "Planning Report N.7, Land-Use Transportation Study", Vol. I (May 1965), Vol. 2 (June 1966), Southeastern Wisconsin Regional Planning Commission.

20. "Base Year Travel Survey," Detroit Regional Transportation and Land Use Study, October 1969.

21. E.A. Beimboon, "Chicago Area Transportation Study" (Vol. 1), 1960.

22. "Characteristics of Taxicab Usage", Highway Research Board, Record No. 250, 1968.

23. "A Modal Split Model for Southeastern Wisconsin", Vol. II, No. 6, "Technical Record", Southeastern Wisconsin Regional Planning Commission, August 1966.

24. "Making Mass Transit Work", Business Week, February 16, 1974.

25. Los Angeles Times, March 27, July 15, 1974.

26. "Financing Metro", W.I. Herman, Transportation Engineering Journal, November 1970.

27. Private Communication from W.I. Herman, Director, Planning Office, WMATA, dated May 3, 1974.

28. "A New Federal Stab at Aiding Mass Transit," Business Week, January 26, 1974.

29. "National Personal Transportation Study: Automobile Occupancy Report No. 1," Federal Highway Administration, April 1972.

30. "A Characterization of Collisions Resulting in Damage and Occupant Injury", Office of Accident Investigation and Data Analysis, Research Institute, Department of Transportation, August 1972.

31. "Analysis of Rollover Accident Factors and Injury Causation", Marsh & Huelke (HSRI), Proceedings 16th Conference of AA for Automotive Medicine, October 1972.

32. "Pedestrian Safety", Operations Research, Silver Springs, Md., January 1971, NTIS PB 197 750.

33. "The Role of Inexperience in Motorcycle Crashes", by Patricia Z. Barry, North Carolina Highway Research Center.

34. "Motorcycle Collision Injuries", by Richard S. Riggins, et al, School of Medicine, University of California at Davis.

35. "Performance Requirements for Motorcycle Helmets", H. Lunenfeld, et al, AIL Report PB 194 567, June 1970.

36. "Some Factors Associated with Severity of Injuries in Motorcycle Collisions", by Jess F. Kraus, et al, School of Medicine, University of California at Davis.

37. "Traffic Safety '72, A Report on Activities Under the Highway Safety Act", U.S. Department of Transportation, October 1973.

38. "Status Report", Insurance Institute for Highway Safety, October 17, 1973.

39. "Using Accident Research to Evaluate Periodic Motor Vehicle Inspection", R.W. McMinn, New Jersey Division of Motor Vehicles, SAE 730706, August 1973.

40. "Performance Requirements for Motorcycle Helmets", H. Lunenfeld, et al, AIL Report PB 194 567, June 1970.

41. "Accident Cause Analysis", K. Perchonsk, Cornell Aeronautical Laboratory, Report PB 212 830, July 1972.

42. "An Evaluation of the Effectiveness of Televised, Locally Oriented Driver Reeducation", J.W. Hutchinson, C.S. Cox, B.R. Maffet, Univ. of Kentucky, Highway Research Record, No. 292.

43. "Alcohol Countermeasures: Solid Rock and Shifting Sands", G.J. Drussan and J.A. Bryk, Journal of Safety Research, September 1973.

44. "An Analysis of ASAP Enforcement Activity", A. Crancer, Jr., DOT, 1973 National Safety Congress Transactions, Vol. 24, Traffic Safety: Driver Improvement.

45. "The British Law on Drinking and Driving: Success and Failure", H.L. Ross, Univ. of Denver, 1973 National Safety Congress Transactions, Vol. 24, Traffic Safety: Driver Improvement.

46. "Improvement Program, Report to the Subcommittee on Investigation and Oversight", Committee on Public Works, House of Representatives, May 26, 1972.

47. "Pedestrian Crosswalk Study: Accidents in Painted and Unpainted Crosswalks", B.F. Herms, Traffic Engineering Section, City of San Diego, Highway Research Record, No. 406, Pedestrian Protection.

48. "Pedestrian Safety, The Identification of Precipitating Factors and Possible Countermeasures", M.B. Snyder, Operations Research Inc., January 1971, Report PB 197 749.

49. "The Elderly Pedestrian: Response to an Enforcement Campaign", E.L. Wiener, Traffic Safety Research Review, Vol. 12, No. 4, December 1968.

50. A Preliminary Report, "Societal Costs of Motor Vehicle Accidents", NHTSA, April 1972.

51. T.E. Anderson, "Analysis of Vehicle Injury Sources", Cornell Aeronautical Laboratory, prepared for NHTSA, September 1972, Contract No. DOT-HS-0531-1-109.

52. D. Huelke, J. Marsh and H. Sherman, "Analysis of Rollover Accident Factors", 16th Conference of American Association for Automotive Medicine.

53. A.J. McClean, "The Man in the Street - Pedestrian Accidents in the Empire State", Proceedings of the 15th Conference of American Association for Automotive Medicine, October 1971.

54. Accident Facts, 1973 Edition.

55. Collision Speeds by Configurations, June 1, 1973, NHTSA.

56. "Problems in Implementing the Highway Safety Improvement Program", Report to the Subcommittee on Investigations and Oversight, Committee on Public Works, House of Representatives, B-164497 (3), May 26, 1972.

57. R.L. Carter, "Passive Protection at 50 Mph", SAE 720445.

58. "Collision Frequency Versus Speed by Injury Level", L. Diminto, J. Marsh, HSRI Report, 1973.

59. "Escapeworthiness of Vehicles and Occupants Survival", C.M. Shipcevich, et al, Univ. of Oklahoma Research Institute, July 1970.

60. "Fire in Motor Vehicle Accidents", Peter Cooley, Highway Safety Research Institute, Univ. of Michigan, HIT Lab Reports, Vol. 5, No. 1, September 1974.

INTRODUCTION

The appendices contained herein present the detailed estimates of the 1972 nationwide accident environment and the corresponding projections for 1985. The following six major accident categories are represented by a separate appendix:

Appendix	Accident Category
A	Motor Vehicle to Motor Vehicle
B	Motor Vehicle to Pedestrians
C.1, .2	Motor Vehicle Collisions with Fixed Objects, On Road and Off Road
D	Motor Vehicle with Pedalcycles
E	Motor Vehicle Rollover
F	Motor Vehicle with Motorcycles

In the various tables that describe a given accident case, individual numerical entries may not add up to the total due to rounding. Similarly, the presence of digit and decade values results in most instances from the calculating devices used rather than estimating preciseness.

APPENDIX A

1972 and 1985

MOTOR VEHICLE TO MOTOR VEHICLE ACCIDENTS

Fatal Accidents: FA

Injury Accidents: IA

Property Damage Accidents: PDA

Fatalities: F

Injuries: I

Fatal-Accident Vehicles: FV

Injury-Accident Vehicles: IV

Property Damage-Accident Vehicles: PDV

When the accident data is disaggregated to the variable levels of vehicle weight and lower, the data represents the involvement of single vehicles rather than accident pairs. For this reason, the data is presented in terms of numbers of vehicles and corresponding fatalities and injuries. The respective definitions for the number of Fatal-Accident Vehicles (FV) and Injury-Accident Vehicles (IV) are as follows: A vehicle involved in an accident is counted as an "FV" if the accident results in a fatality or an "IV" if the accident results in an injury but not a fatality. If a vehicle is in an accident but no injuries or fatalities occur, that vehicle is counted as a Property Damage-Accident Vehicle (PDV).

TABLE A.1

URBAN AREA ACCIDENTS, 1972
BY VEHICLE WEIGHT AND PRIMARY DAMAGE AREA

FA	5,500
IA	1,679,600
PDA	3,728,400
F	5,900
I	2,686,400

Vehicle #1 Weight <3000 lbs

FV	2,640	F	1,416
IV	739,000	I	591,008
PDV	1,566,000		

Vehicle #1 Weight > 3000 lbs

F	4,484	FV	8,360
I	2,095,392	IV	2,620,000
		PDV	5,890,800

TABLE A.2

RURAL AREA ACCIDENTS, 1972
BY VEHICLE #1 WEIGHT AND PRIMARY DAMAGE AREA

FA	13,400
IA	908,400
PDA	1,407,200
F	18,300
I	1,616,950

Vehicle #1 Weight <3000 lbs

FV	6,700	F	4,575
IV	417,800	I	371,899
PDV	647,400		

Vehicle #1 Weight > 3000 lbs

F	13,725	FV	20,100
I	1,245,051	IV	1,399,000
		PDV	2,167,000

TABLE A.3

URBAN AREA ACCIDENTS, 1972

Vehicle Weight <3000 lbs
Primary Damage Area: Front

FV 2,200 F 1,180
IV 441,920 I 353,423

Relative Impact Speed:	0-20 MPH	21-40	41-60	>60
F V	106	314	382	1,400
I V	215,220	153,790	49,930	22,980
F	57	169	205	749
I	172,117	122,991	39,937	18,378

TABLE A.4

URBAN AREA ACCIDENTS, 1972

Vehicle Weight <3000 lbs
Primary Damage Area: Side

FV 320 F 177
IV 90,900 I 72,694

Relative Impact Speed:	0-20 MPH	21-40	41-60	> 60
F V	126	98	78	30
I V	58,180	28,800	3,636	272
F	68	52	42	16
I	46,524	23,044	2,908	218

TABLE A.5

URBAN AREA ACCIDENTS, 1972

Vehicle Weight <3000 lbs
Primary Damage Area: Rear

FV	110	F	59
IV	206,180	I	164,891

Relative Impact Speed:	0-20 MPH	21-40	41-60	>60
FV	94	14	2	0
IV	175,870	28,040	2,268	0
F	50	8	1	0
I	140,652	22,425	1,814	0

TABLE A.6

URBAN AREA ACCIDENTS, 1972

Vehicle Weight <3000 lbs
Primary Damage Area: Front

FV	6,160	F	3,308
IV	1,577,360	I	1,261,426

Relative Impact Speed:	0-20 MPH	21-40	41-60	>60
FV	296	880	1,072	3,910
IV	768,170	548,920	178,240	82,020
F	159	473	576	2,101
I	614,314	438,976	142,541	65,594

TABLE A.7

URBAN AREA ACCIDENTS, 1972

Vehicle Weight >3000 lbs
Primary Damage Area: Side

FV	1,780	F	960
IV	317,040	I	253,542

Relative Impact Speed:	0-20 MPH	21-40	41-60	>60
FV	680	524	420	156
IV	202,910	100,500	12,680	952
F	367	282	227	84
I	162,267	80,373	10,142	761

TABLE A.8

URBAN AREA ACCIDENTS, 1972

Vehicle Weight >3000 lbs
Primary Damage Area: Rear

FV	420	F	216
IV	725,800	I	580,424

Relative Impact Speed:	0-20 MPH	21-40	41-60	> 60
FV	358	58	4	0
IV	619,100	98,710	7,984	0
F	184	29	3	0
I	495,102	78,938	6,385	0

TABLE A.9

RURAL AREA ACCIDENTS, 1972

Vehicle Weight <3000 lbs
Primary Damage Area: Front

FV	4,520	F	3,093
IV	262,400	I	233,552

Relative Impact Speed:	0-20 MPH	21-40	41-60	>60
FV	216	646	786	2,870
IV	127,790	91,320	29,650	13,640
F	148	442	538	1,964
I	113,740	81,276	26,391	12,145

TABLE A.10

RURAL AREA ACCIDENTS, 1972

Vehicle Weight <3000 lbs
Primary Damage Area: Side

FV	1,640	F	1,112
IV	54,680	I	48,719

Relative Impact Speed:	0-20 MPH	21-40	41-60	>60
FV	626	482	388	142
IV	34,996	17,334	2,188	164
F	425	327	262	98
I	31,180	15,444	1,949	146

TABLE A.11

RURAL AREA ACCIDENTS, 1972

Vehicle Weight <3000 lbs
Primary Damage Area: Rear

FV	540	F	370
IV	100,720	I	89,628

Relative Impact Speed:	0-20 MPH	21-40	41-60	>60
FV	460	74	6	0
IV	85,914	13,698	1,108	0
F	316	50	4	0
I	76,453	12,189	986	0

TABLE A.12

RURAL AREA ACCIDENTS, 1972

Vehicle Weight >3000 lbs
Primary Damage Area: Front

FV	15,520	F	10,596
IV	845,000	I	698,474

Relative Impact Speed:	0-20 MPH	21-40	41-60	> 60
FV	744	2,220	2,700	9,856
IV	411,516	294,060	95,486	43,940
F	509	1,515	1,844	6,728
I	340,157	243,069	78,928	36,321

TABLE A.13

RURAL AREA ACCIDENTS, 1972

Vehicle Weight >3000 lbs
Primary Damage Area: Side

FV	3,380	F	2,306
IV	165,080	I	164,347

Relative Impact Speed:	0-20 MPH	21-40	41-60	>60
FV	1,292	994	798	298
IV	105,652	52,330	6,604	496
F	881	678	544	203
I	105,182	52,098	6,574	493

TABLE A.14

RURAL AREA ACCIDENTS, 1972

Vehicle Weight >3000 lbs
Primary Damage Area: Rear

FV	1,200	F	823
IV	388,920	I	382,230

Relative Impact Speed:	0-20 MPH	21-40	41-60	> 60
FV	1,024	164	14	0
IV	331,748	52,894	4,278	0
F	702	112	9	0
I	326,042	51,983	4,205	0

TABLE A.15

URBAN AREA ACCIDENTS, 1985
BY VEHICLE WEIGHT AND PRIMARY DAMAGE AREA

FA	8,471
IA	2,159,000
PDA	4,719,400
F	9,064
I	3,454,000

Vehicle #1 Weight <3000 lbs

FV	4,744	F	2,538
IV	1,079,400	I	863,500
PDV	2,265,400		

Vehicle #1 Weight > 3000 lbs

FV	12,198	F	6,526
IV	3,238,000	I	2,590,500
PDV	7,173,400		

TABLE A.16

RURAL AREA ACCIDENTS, 1985
BY VEHICLE #1 WEIGHT AND PRIMARY DAMAGE AREA

FA	15,059
IA	1,016,000
PDA	1,573,000
F	20,630
I	1,808,500

Vehicle #1 Weight <3000 lbs

FV	8,734	F	5,983
IV	528,000	I	470,210
PDV	818,000		

Vehicle #1 Weight > 3000 lbs

FV	21,384	F	14,647
IV	1,504,000	I	1,338,290
PDV	2,328,000		

TABLE A.17

URBAN AREA ACCIDENTS, 1985

Vehicle Weight <3000 lbs
Primary Damage Area: Front

FV	3,952	F	2,152
IV	645,482	I	516,373

Relative Impact Speed:	0-20 MPH	21-40	41-60	>60
FV	190	566	688	2,510
IV	314,350	224,628	72,940	33,566
F	103	308	374	1,367
I	251,474	179,698	58,350	26,851

TABLE A.18

URBAN AREA ACCIDENTS, 1985

Vehicle Weight <3000 lbs
Primary Damage Area: Side

FV	594	F	323
IV	132,766	I	106,210

Relative Impact Speed:	0-20 MPH	21-40	41-60	>60
FV	226	174	140	52
IV	84,970	42,086	5,312	398
F	123	95	76	28
I	67,974	33,669	4,248	319

TABLE A.19

URBAN AREA ACCIDENTS, 1985

Vehicle Weight <3000 lbs
Primary Damage Area: Rear

FV	198
IV	301,152
F	108
I	240,917

Relative Impact Speed:

	0-20 MPH	21-40	41-60	>60
FV	168	26	2	0
IV	256,882	40,956	2,312	0
F	92	15	1	0
I	205,502	32,765	2,650	0

TABLE A.20

URBAN AREA ACCIDENTS, 1985

Vehicle Weight > 3000 lbs
Primary Damage Area: Front

FV	9,002
IV	1,949,638
F	4,816
I	1,559,481

Relative Impact Speed:

	0-20 MPH	21-40	41-60	> 60
FV	432	1,288	1,566	5,716
IV	949,474	678,474	220,310	101,382
F	231	689	838	3,058
I	759,467	542,699	176,221	81,093

TABLE A.21

URBAN AREA ACCIDENTS, 1985

Vehicle #1 Weight >3000 lbs
Primary Damage Area: Side

FV	2,610
IV	391,870
F	1,397
I	313,450

Impact Speed:	0-20 MPH	21-40	41-60	>60
FV	998	768	616	230
IV	250,796	124,222	15,674	1,176
F	534	411	330	123
I	200,608	99,364	12,538	940

TABLE A.22

URBAN AREA ACCIDENTS, 1985

Vehicle #1 Weight > 3000 lbs
Primary Damage Area: Rear

FV	586
IV	897,092
F	313
I	717,569

Impact Speed:	0-20 MPH	21-40	41-60	> 60
FV	500	80	6	0
IV	765,220	122,004	9,868	0
F	267	43	3	0
I	612,086	97,589	7,893	0

TABLE A.23

RURAL AREA ACCIDENTS, 1985

Vehicle #1 Weight <3000 lbs
Primary Damage Area: Front

FV	5,904
IV	331,584
F	4,045
I	295,292

Impact Speed:	0-20 MPH	21-40	41-60	>60
FV	284	844	1,028	3,750
IV	161,482	115,392	37,468	17,242
F	194	578	704	2,569
I	143,807	102,762	33,368	15,355

TABLE A.24

RURAL AREA ACCIDENTS, 1985

Vehicle #1 Weight <3000 lbs
Primary Damage Area: Side

FV	2,122
IV	69,168
F	1,454
I	61,598

Impact Speed:	0-20 MPH	21-40	41-60	> 60
FV	810	624	500	186
IV	44,268	21,926	2,766	208
F	555	427	343	128
I	39,523	19,527	2,464	185

TABLE A.25

RURAL AREA ACCIDENTS, 1985

Vehicle #1 Weight <3000 lbs
Primary Damage Area: Rear

FV	708
IV	127,248
F	484
I	113,320

Impact Speed:

0-20 MPH		21-40	41-60	>60	
FV	604	96	8	FA	0
IV	108,542	17,306	1,400	IA	0
F	413	66	5	F	0
I	96,632	15,412	1,247	I	0

TABLE A.26

RURAL AREA ACCIDENTS, 1985

Vehicle #1 Weight > 3000 lbs
Primary Damage Area: Front

FV	16,508
IV	908,416
F	11,307
I	808,327

Impact Speed:

0-20 MPH		21-40	41-60	> 60
FV	792	2,360	2,872	10,482
IV	442,398	316,128	102,652	47,238
F	543	1,617	1,964	7,180
I	393,655	281,298	91,341	42,033

TABLE A.27

RURAL AREA ACCIDENTS, 1985

Vehicle #1 Weight > 3000 lbs
Primary Damage Area: Side

FV	3,592
IV	177,472
F	2,461
I	157,918

Impact Speed:	0-20 MPH	21-40	41-60	>60
FV	1,372	1,056	848	316
IV	113,582	56,258	7,098	532
F	940	724	581	217
I	101,068	50,060	6,317	474

TABLE A.28

RURAL AREA ACCIDENTS, 1985

Vehicle #1 Weight > 3000 lbs
Primary Damage Area: Rear

FV	1,284
IV	418,112
F	879
I	372,045

Impact Speed:	0-20 MPH	21-40	41-60	> 60	
FV	1,096	174	14	FA	0
IV	356,650	56,864	4,600	IA	0
F	750	120	10	F	0
I	317,354	50,591	4,092	I	0

APPENDIX B

1972 and 1985

MOTOR VEHICLE WITH PEDESTRIAN ACCIDENTS

Fatal Accidents:	FA
Injury Accidents:	IA
Property Damage Accidents:	PDA
Fatalities:	F
Injuries:	I

TABLE B.1

URBAN AREA ACCIDENTS, 1972
BY VEHICLE WEIGHT AND PRIMARY COLLISION AREA

FA	6,800
IA	228,655
F	6,800
I	242,375

Vehicle #1 Weight <3000 lbs

FA	1,632
IA	50,990
F	1,632
I	54,050

	Front	Side	Rear
FA	1,632	0	0
IA	44,004	4,386	2,600
F	1,632	0	0
I	46,645	4,648	2,757

Vehicle #1 Weight > 3000 lbs

FA	5,168
IA	177,665
F	5,168
I	188,325

	Front	Side	Rear
FA	4,796	124	248
IA	153,147	14,036	10,482
F	4,796	124	248
I	162,336	14,878	11,111

TABLE B.2

RURAL AREA ACCIDENTS, 1972
BY VEHICLE WEIGHT AND PRIMARY COLLISION AREA

FA	3,700
IA	32,665
F	3,900
I	34,625

Vehicle #1 Weight <3000 lbs

FA	925
IA	7,546
F	975
I	7,998

	Front	Side	Rear
FA	925	0	0
IA	6,814	611	121
F	975	0	0
I	7,222	648	128

Vehicle #1 Weight >3000 lbs

FA	2,775
IA	25,119
F	2,925
I	26,627

	Front	Side	Rear
FA	2,570	0	205
IA	20,673	3,366	1,080
F	2,709	0	216
I	21,914	3,568	1,145

TABLE B.3

URBAN AREA ACCIDENTS, 1972
VEHICLE #1 WEIGHT <3000 LBS
PRIMARY COLLISION AREA: FRONT

FA 1,632
IA 44,004
F 1,632
I 46,645

Impact Speed:	0-20 MPH	21-40	> 40
FA	653	811	168
IA	25,742	17,822	440
F	653	811	168
I	27,287	18,891	467

TABLE B.4

URBAN AREA ACCIDENTS, 1972
VEHICLE #1 WEIGHT <3000 LBS
PRIMARY COLLISION AREA: SIDE

FA 0
IA 4,386
F 0
I 4,648

Impact Speed:	0-20 MPH	21-40	> 40
FA	0	0	0
IA	2,566	1,776	44
F	0	0	0
I	2,719	1,882	47

TABLE B.5

URBAN AREA ACCIDENTS, 1972
VEHICLE #1 WEIGHT <3000 LBS
PRIMARY COLLISION AREA: REAR

FA	0
IA	2,600
F	0
I	2,757

Impact Speed:	0-20 MPH	21-40	> 40
FA	0	0	0
IA	2,600	0	0
F	0	0	0
I	2,757	0	0

TABLE B.6

URABN AREA ACCIDENTS, 1972
VEHICLE #1 WEIGHT >3000 LBS
PRIMARY COLLISION AREA: FRONT

FA	4,796
IA	153,147
F	4,796
I	162,336

Impact Speed:	0-20 MPH	21-40	> 40
FA	1,918	2,384	494
IA	89,591	62,025	1,531
F	1,918	2,384	494
I	94,967	65,746	1,623

TABLE B.7

URBAN AREA ACCIDENTS, 1972
VEHICLE #1 WEIGHT >3000 LBS
PRIMARY COLLISION AREA: SIDE

	Total
FA	124
IA	14,036
F	124
I	14,878

Impact Speed:	0-20 MPH	21-40	> 40
FA	50	62	13
IA	8,211	5,685	140
F	50	62	13
I	8,703	6,026	149

TABLE B.8

URBAN AREA ACCIDENTS, 1972
VEHICLE #1 WEIGHT >3000 LBS
PRIMARY COLLISION AREA: REAR

	Total
FA	248
IA	10,482
F	248
I	11,111

Impact Speed:	0-20 MPH	21-40	> 40
FA	248	0	0
IA	10,482	0	0
F	248	0	0
I	11,111	0	0

TABLE B.9

RURAL AREA ACCIDENTS, 1972
VEHICLE #1 WEIGHT <3000 LBS
PRIMARY COLLISION AREA: FRONT

FA 925
IA 6,814
F 975
I 7,222

Impact Speed:	0-20 MPH	21-40	> 40
FA	370	460	95
IA	3,986	2,760	68
F	390	485	100
I	4,225	2,925	72

TABLE B.10

RURAL AREA ACCIDENTS, 1972
VEHICLE #1 WEIGHT <3000 LBS
PRIMARY COLLISION AREA: SIDE

FA 0
IA 611
F 0
I 648

Impact Speed:	0-20 MPH	21-40	> 40
FA	0	0	0
IA	358	247	6
F	0	0	0
I	380	262	6

TABLE B.11

RURAL AREA ACCIDENTS, 1972
VEHICLE #1 WEIGHT <3000 LBS
PRIMARY COLLISION AREA: REAR

Total: FA 0, IA 121, F 0, I 128

Impact Speed:	0-20 MPH	21-40	> 40
FA	0	0	0
IA	121	0	0
F	0	0	0
I	128	0	0

TABLE B.12

RURAL AREA ACCIDENTS, 1972
VEHICLE #1 WEIGHT >3000 LBS
PRIMARY COLLISION AREA: FRONT

Total: FA 2,570, IA 20,673, F 2,709, I 21,914

Impact Speed:	0-20 MPH	21-40	> 40
FA	1,028	1,277	265
IA	12,094	8,373	207
F	1,084	1,346	279
I	12,820	8,875	219

TABLE B.13

RURAL AREA ACCIDENTS, 1972
VEHICLE #1 WEIGHT >3000 LBS
PRIMARY COLLISION AREA: SIDE

	Total
FA	0
IA	3,366
F	0
I	3,568

Impact Speed:	0-20 MPH	21-40	>40
FA	0	0	0
IA	1,969	1,363	34
F	0	0	0
I	2,087	1,445	36

TABLE B.14

RURAL AREA ACCIDENTS, 1972
VEHICLE #1 WEIGHT >3000 LBS
PRIMARY COLLISION AREA: REAR

	Total
FA	205
IA	1,080
F	216
I	1,145

Impact Speed:	0-20 MPH	21-40	>40
FA	205	0	0
IA	1,080	0	0
F	216	0	0
I	1,145	0	0

TABLE B.15

URBAN AREA ACCIDENTS, 1972
VEHICLE #1 WEIGHT <3000 LBS
PRIMARY COLLISION AREA: FRONT
IMPACT SPEED: 0-20 mph

	Total
FA	653
IA	25,742
F	653
I	27,287

Victim Age (Years)	<5	5-14	15-24	25-44	45-64	>64
FA	49	122	86	98	140	159
IA	2,574	10,297	4,299	3,655	2,986	1,931
F	49	122	86	98	140	159
I	2,729	10,914	4,557	3,875	3,165	2,047

TABLE B.16

URBAN AREA ACCIDENTS, 1972
VEHICLE #1 WEIGHT <3000 LBS
PRIMARY COLLISION AREA: FRONT
IMPACT SPEED: 21-40 mph

	Total
FA	811
IA	17,822
F	811
I	18,891

Victim Age (Years)	<5	5-14	15-24	25-44	45-64	>64
FA	61	152	106	122	174	197
IA	1,782	7,129	2,976	2,531	2,067	1,337
F	61	152	106	122	174	197
I	1,889	7,556	3,155	2,683	2,191	1,417

TABLE B.17

URBAN AREA ACCIDENTS, 1972
VEHICLE #1 WEIGHT <3000 LBS
PRIMARY COLLISION AREA: FRONT
IMPACT SPEED: >40 mph

FA 168
IA 440
F 168
I 407

Victim Age (Years)	<5	5-14	15-24	25-44	45-64	>64
FA		31	22	25	36	41
IA		177	73	62	51	33
F	13	31	22	25	36	41
I	47	187	78	66	54	35

TABLE B.18

URBAN AREA ACCIDENTS, 1972
VEHICLE #1 WEIGHT <3000 LBS
PRIMARY COLLISION AREA: SIDE
IMPACT SPEED: 0-20 mph

FA 0
IA 2,566
F 0
I 2,719

Victim Age (Years)	<5	5-14	15-24	25-44	45-64	>64
FA	0	0	0	0	0	0
IA	257	1,026	429	364	298	192
F	0	0	0	0	0	0
I	272	1,088	454	386	315	204

TABLE B.19

URBAN AREA ACCIDENTS, 1972
VEHICLE #1 WEIGHT <3000 LBS
PRIMARY COLLISION AREA: SIDE

FA 0
IA 1,776
F 0
I 1,882

Victim Age (Years)	<5	5-14	15-24	25-44	45-64	>64
FA	0	0	0	0	0	0
IA	178	710	297	252	206	133
F	0	0	0	0	0	0
I	188	753	314	267	218	142

TABLE B.20

URBAN AREA ACCIDENTS, 1972
VEHICLE #1 WEIGHT <3000 LBS
PRIMARY COLLISION AREA: SIDE
IMPACT SPEED: >40 mph

FA 0
IA 44
F 0
I 47

Victim Age (Years)	<5	5-14	15-24	25-44	45-64	>64
FA	0	0	0	0	0	0
IA	4	19	7	6	5	3
F	0	0	0	0	0	0
I	5	19	8	7	5	3

TABLE B.21

URBAN AREA ACCIDENTS, 1972
VEHICLE #1 WEIGHT <3000 LBS
PRIMARY COLLISION AREA: REAR
IMPACT SPEED: 0-20 mph

FA 0
IA 2,600
F 0
I 2,757

Victim Age (Years)	<5	5-14	15-24	25-44	45-64	>64
FA	0	0	0	0	0	0
IA	260	1,040	434	369	302	195
F	0	0	0	0	0	0
I	276	1,103	460	391	320	207

TABLE B.22

URBAN AREA ACCIDENTS, 1972
VEHICLE #1 WEIGHT >3000 LBS
PRIMARY COLLISION AREA: FRONT
IMPACT SPEED: 0-20 mph

FA 1,918
IA 89,591
F 1,918
I 94,967

Victim Age (Years)	<5	5-14	15-24	25-44	45-64	>64
FA	144	359	251	286	412	466
IA	8,959	35,836	14,962	12,722	10,393	6,719
F	144	359	251	286	412	466
I	9,497	37,987	15,859	13,485	11,016	7,123

TABLE B.23

URBAN AREA ACCIDENTS, 1972
VEHICLE #1 WEIGHT >3000 LBS
PRIMARY COLLISION AREA: FRONT
IMPACT SPEED: 21-40 mph

FA 2,384
IA 62,025
F 2,384
I 65,746

Victim Age (Years)	<5	5-14	15-24	25-44	45-64	>64
FA	179	446	312	355	513	579
IA	6,203	24,810	10,357	8,808	7,195	4,652
F	179	446	312	355	513	579
I	6,575	26,298	10,980	9,335	7,627	4,931

TABLE B.24

URBAN AREA ACCIDENTS, 1972
VEHICLE #1 WEIGHT >3000 LBS
PRIMARY COLLISION AREA: FRONT
IMPACT SPEED: >40 mph

FA 494
IA 1,531
F 494
I 1,623

Victim Age (Years)	<5	5-14	15-24	25-44	45-64	>64
FA	37	92	65	74	106	120
IA	153	612	256	217	178	115
F	37	92	65	74	106	120
I	162	649	272	230	188	122

TABLE B.25

URBAN AREA ACCIDENTS, 1972
VEHICLE #1 WEIGHT >3000 LBS
PRIMARY COLLISION AREA: SIDE
IMPACT SPEED: 0-20 mph

FA 50
IA 8,211
F 50
I 8,703

Victim Age (Years)	<5	5-14	15-24	25-44	45-64	>64
FA	4	9	7	7	11	12
IA	821	3,284	1,372	1,166	952	616
F	4	9	7	7	11	12
I	870	3,481	1,453	1,236	1,010	653

TABLE B.26

URBAN AREA ACCIDENTS, 1972
VEHICLE #1 WEIGHT >3000 LBS
PRIMARY COLLISION AREA: SIDE
IMPACT SPEED: 21-40 mph

FA 62
IA 5,685
F 62
I 6,026

Victim Age (Years)	<5	5-14	15-24	25-44	45-64	>64
FA	5	12	8	9	13	15
IA	569	2,214	949	808	659	426
F	5	12	8	9	13	15
I	603	2,410	1,006	856	699	452

TABLE B.27

URBAN AREA ACCIDENTS, 1972
VEHICLE #1 WEIGHT >3000 LBS
PRIMARY COLLISION AREA: SIDE
IMPACT SPEED: >40 mph

FA 13
IA 140
F 13
I 149

Victim Age (Years)	<5	5-14	15-24	25-44	45-64	>64
FA	1	2	2	2	3	3
IA	14	56	23	20	16	11
F	1	2	2	2	3	3
I	15	60	25	21	17	11

TABLE B.28

URBAN AREA ACCIDENTS, 1972
VEHICLE #1 WEIGHT >3000 LBS
PRIMARY COLLISION AREA: REAR
IMPACT SPEED: 0-20 mph

FA 248
IA 10,482
F 248
I 11,111

Victim Age (Years)	<5	5-14	15-24	25-44	45-64	>64
FA	19	46	32	37	53	60
IA	1,048	4,193	1,750	1,488	1,216	786
F	19	46	32	37	53	60
I	1,111	4,444	1,856	1,578	1,289	833

TABLE B.29

RURAL AREA ACCIDENTS, 1972
VEHICLE #1 WEIGHT <3000 LBS
PRIMARY COLLISION AREA: FRONT
IMPACT SPEED: 0-20 mph

FA 370
IA 3,986
F 390
I 4,225

Victim Age (Years)	<5	5-14	15-24	25-44	45-64	>64
FA	28	69	48	55	80	90
IA	399	1,594	666	566	462	299
F	29	73	51	58	84	95
I	423	1,689	706	600	490	317

TABLE B.30

RURAL AREA ACCIDENTS, 1972
VEHICLE #1 WEIGHT <3000 LBS
PRIMARY COLLISION AREA: FRONT
IMPACT SPEED: 21-40 mph

FA 460
IA 2,760
F 485
I 2,925

Victim Age (Years)	<5	5-14	15-24	25-44	45-64	>64
FA	35	86	60	69	99	112
IA	276	1,104	460	392	320	207
F	36	91	64	72	104	118
I	293	1,171	488	415	339	219

TABLE B.31

RURAL AREA ACCIDENTS, 1972
VEHICLE #1 WEIGHT <3000 LBS
PRIMARY COLLISION AREA: FRONT
IMPACT SPEED: >40 mph

FA 95
IA 68
F 100
I 72

Victim Age (Years)

	<5	5-14	15-24	25-44	45-64	>64
FA	7	18	12	14	20	23
IA	7	27	11	10	8	5
F	8	19	13	15	22	24
I	7	29	12	11	8	5

TABLE B.32

RURAL AREA ACCICENTS, 1972
VEHICLE #1 WEIGHT <3000 LBS
PRIMARY COLLISION AREA: SIDE
IMPACT SPEED: 0-20 mph

FA 0
IA 358
F 0
I 380

Victim Age (Years)

	<5	5-14	15-24	25-44	45-64	>64
FA	0	0	0	0	0	0
IA	36	143	60	50	42	27
F	00	0	0	0	0	0
I	38	152	63	54	44	29

TABLE B.33

RURAL AREA ACCIDENTS, 1972
VEHICLE #1 WEIGHT <3000 LBS
PRIMARY COLLISION AREA: SIDE
IMPACT SPEED: 21-40 mph

FA 0
IA 247
F 0
I 262

Victim Age (Years)

	<5	5-14	15-24	25-44	45-64	>64
FA	0	0	0	0	0	0
IA	25	99	40	35	29	19
F	0	0	0	0	0	0
I	26	105	44	37	30	20

TABLE B.34

RURAL AREA ACCIDENTS, 1972
VEHICLE #1 WEIGHT <3000 LBS
PRIMARY COLLISION AREA: SIDE
IMPACT SPEED: >40 mph

FA 0
IA 6
F 0
I 6

Victim Age (Years)

	<5	5-14	15-24	25-44	45-64	>64
FA	0	0	0	0	0	0
IA	1	1	1	1	1	1
F	0	0	0	0	0	0
I	1	1	1	1	1	1

TABLE B.35

RURAL AREA ACCIDENTS, 1972
VEHICLE #1 WEIGHT <3000 LBS
PRIMARY COLLISION AREA: REAR
IMPACT SPEED: 0-20 mph

	Total
FA	0
IA	121
F	0
I	128

Victim Age (Years)	<5	5-14	15-24	25-44	45-64	>64
FA	0	0	0	0	0	0
IA	12	48	20	17	14	9
F	0	0	0	0	0	0
I	13	51	21	18	15	10

TABLE B.36

RURAL AREA ACCIDENTS, 1972
VEHICLE #1 WEIGHT >3000 LBS
PRIMARY COLLISION AREA: FRONT
IMPACT SPEED: 0-20 mph

	Total
FA	1,028
IA	12,094
F	1,084
I	12,820

Victim Age (Years)	<5	5-14	15-24	25-44	45-64	>64
FA	77	192	135	153	221	250
IA	1,209	4,838	2,020	1,717	1,403	907
F	81	203	142	162	233	263
I	1,282	5,128	2,141	1,820	1,487	962

TABLE B.37

1972

RURAL AREA ACCIDENTS

Vehicle #1 Weight > 3,000 lb
Primary Collision Area: Front
Impact Speed: 21-40 mph

FA	1,277
IA	8,373
F	1,346
I	8,875

Victim Age (Years)

	<5	5-14	15-24	25-44	45-64	>64
FA	96	239	167	190	275	310
IA	837	3,349	1,398	1,189	972	628
F	101	252	176	201	289	327
I	888	3,550	1,481	1,260	1,030	666

TABLE B.38

1972

RURAL AREA ACCIDENTS

Vehicle #1 Weight > 3,000 lb
Primary Collision Area: Front
Impact Speed: >40 mph

FA	265
IA	207
F	279
I	219

Victim Age (Years)

	<5	5-14	15-24	25-44	45-64	>64
FA	20	50	35	39	57	64
IA	21	82	35	29	24	16
F	21	52	37	42	60	68
I	22	88	37	31	25	16

TABLE B.39

1972

RURAL AREA ACCIDENTS

Vehicle #1 Weight > 3,000 lb
Primary Collision Area: Side
Impact Speed: 0-20 mph

FA	0
IA	1,969
F	0
I	2,087

Victim Age (Years)	<5	5-14	15-24	25-44	45-64	>64
FA	0	0	0	0	0	0
IA	197	787	329	280	228	148
F	0	0	0	0	0	0
I	209	834	349	296	242	157

TABLE B.40

1972

RURAL AREA ACCIDENTS

Vehicle #1 Weight > 3,000 lb
Primary Collision Area: Side
Impact Speed: 21-40 mph

FA	0
IA	1,363
F	0
I	1,445

Victim Age (Years)	<5	5-14	15-24	25-44	45-64	>64
FA	0	0	0	0	0	0
IA	136	545	228	194	158	102
F	0	0	0	0	0	0
I	478	578	241	205	168	108

TABLE B.41

1972

RURAL AREA ACCIDENTS

Vehicle #1 Weight > 3,000 lb
Primary Collision Area: Side
Impact Speed: >40 mph

FA 0
IA 34
F 0
I 36

Victim Age (Years)	<5	5-14	15-24	25-44	45-64	>64
FA	0	0	0	0	0	0
IA	3	13	6	5	4	3
F	0	0	0	0	0	0
I	4	14	6	5	4	3

TABLE B.42

1972

RURAL AREA ACCIDENTS

Vehicle #1 Weight > 3,000 lb
Primary Collision Area: Rear
Impact Speed: 0-20 mph

FA 205
IA 1,080
F 216
I 1,145

Victim Age (Years)	<5	5-14	15-24	25-44	45-64	>64
FA	15	38	27	31	44	50
IA	108	432	180	153	125	81
F	16	40	28	32	46	52
I	115	458	191	163	133	86

TABLE B.43

URBAN AREA ACCIDENTS, 1985
BY VEHICLE WEIGHT AND PRIMARY COLLISION AREA

	Total
FA	7,484
IA	234,272
F	7,631
I	248,325

Vehicle #1 Weight <3000 lbs

	Total
FA	2,096
IA	58,568
F	2,137
I	62,081

	Front	Side	Rear
FA	2,096	0	0
IA	50,544	5,037	2,987
F	2,137	0	0
I	53,576	5,339	3,166

Vehicle #1 Weight > 3000 lbs

	Total
FA	5,388
IA	175,704
F	5,494
I	186,244

	Front	Side	Rear
FA	5,000	129	259
IA	151,457	13,881	10,367
F	5,098	132	264
I	160,542	14,713	10,988

TABLE B.44

RURAL AREA ACCIDENTS, 1985
BY VEHICLE WEIGHT AND PRIMARY COLLISION AREA

	Total
FA	4,066
IA	33,468
F	4,145
I	35,475

Vehicle #1 Weight <3000 lbs

	Total
FA	1,179
IA	8,702
F	1,202
I	9,223

	Front	Side	Rear
FA	1,179	0	0
IA	7,858	705	139
F	1,202	0	0
I	8,328	747	148

Vehicle #1 Weight > 3000 lbs

	Total
FA	2,887
IA	24,766
F	2,943
I	26,252

	Front	Side	Rear
FA	2,673	0	214
IA	20,382	3,319	1,065
F	2,725	0	218
I	21,605	3,518	1,129

TABLE B.45

1985

URBAN AREA ACCIDENTS

Vehicle #1 Weight < 3,000 lb
Primary Collision Area: Front

FA	2,096
IA	50,544
F	2,137
I	53,576

Impact Speed:		0-20 MPH	21-40	> 40
	FA	838	1,042	216
	IA	29,568	20,470	505
	F	855	1,062	220
	I	31,342	21,698	536

TABLE B.46

1985

URBAN AREA ACCIDENTS

Vehicle #1 Weight < 3,000 lb
Primary Collision Area: Side

FA	0
IA	5,037
F	0
I	5,339

Impact Speed:		0-20 MPH	21-40	> 40
	FA	20	0	0
	IA	2,947	2,040	50
	F	0	0	0
	I	3,123	2,162	54

TABLE B.47

1985

URBAN AREA ACCIDENTS

Vehicle #1 Weight < 3,000 lb
Primary Collision Area: Rear

FA	0
IA	2,987
F	0
I	3,166

Impact Speed:	0-20 MPH	21-40	> 40
FA	0	0	0
IA	2,987	0	0
F	0	0	0
I	3,166	0	0

TABLE B.48

1985

URBAN AREA ACCIDENTS

Vehicle #1 Weight > 3,000 lb
Primary Collision Area: Front

FA	5,000
IA	151,457
F	5,098
I	160,542

Impact Speed:	0-20 MPH	21-40	> 40
FA	2,000	2,485	515
IA	88,602	61,340	1,515
F	2,039	2,534	525
I	93,917	65,020	1,605

TABLE B.49

1985

URBAN AREA ACCIDENTS

Vehicle #1 Weight > 3,000 lb
Primary Collision Area: Side

FA	129
IA	13,881
F	132
I	14,713

Impact Speed:

	0-20 MPH	21-40	> 40
FA	52	64	13
IA	8,120	5,622	139
F	53	66	14
I	8,607	5,959	147

TABLE B.50

1985

URBAN AREA ACCIDENTS

Vehicle #1 Weight > 3,000 lb
Primary Collision Area: Rear

FA	259
IA	10,367
F	264
I	10,988

Impact Speed:

	0-20 MPH	21-40	> 40
FA	259	0	0
IA	10,367	0	0
F	264	0	0
I	10.988	0	0

TABLE B.51

1985

RURAL AREA ACCIDENTS

Vehicle #1 Weight < 3,000 lb
Primary Collision Area: Front

FA	1,179
IA	7,858
F	1,202
I	8,328

Impact Speed:	0-20 MPH	21-40	> 40
FA	472	586	121
IA	4,597	3,182	79
F	481	597	124
I	4,872	3,373	83

TABLE B.52

1985

RURAL AREA ACCIDENTS

Vehicle #1 Weight < 3,000 lb
Primary Collision Area: Side

FA	0
IA	705
F	0
I	747

Impact Speed:	0-20 MPH	21-40	> 40
FA	0	0	0
IA	412	286	7
F	0	0	0
I	437	303	7

TABLE B.53

1985

RURAL AREA ACCIDENTS

Vehicle #1 Weight < 3,000 lb
Primary Collision Area: Rear

FA	0
IA	139
F	0
I	148

Impact Speed:	0-20 MPH	21-40	> 40
FA	0	0	0
IA	139	0	0
F	0	0	0
I	148	0	0

TABLE B.54

1985

RURAL AREA ACCIDENTS

Vehicle #1 Weight > 3,000 lb
Primary Collision Area: Front

FA	2,887
IA	24,766
F	2,943
I	26,252

Impact Speed:	0-20 MPH	21-40	> 40
FA	1,155	1,435	297
IA	14,488	10,030	248
F	1,177	1,463	303
I	15,357	10,632	263

TABLE B.55

1985

RURAL AREA ACCIDENTS

Vehicle #1 Weight > 3,000 lb
Primary Collision Area: Side

FA	0
IA	3,319
F	0
I	3,518

Impact Speed:

	0-20 MPH	21-40	> 40
FA	0	0	0
IA	1,942	1,344	33
F	0	0	0
I	2,058	1,425	35

TABLE B.56

1985

RURAL AREA ACCIDENTS

Vehicle #1 Weight > 3,000 lb
Primary Collision Area: Rear

FA	214
IA	1,065
F	218
I	1,129

Impact Speed:

	0-20 MPH	21-40	> 40
FA	214	0	0
IA	1,065	0	0
F	218	0	0
I	1,129	0	0

TABLE B.57

1985

URBAN AREA ACCIDENTS

Vehicle #1 Weight < 3,000 lb
Primary Collision Area: Front
Impact Speed: 0-20 mph

FA	838
IA	29,568
F	855
I	31,342

Victim Age (Years)	<5	5-14	15-24	25-44	45-64	>64
FA	59	121	99	163	167	229
IA	3,016	9,787	4,790	5,884	3,400	2,691
F	61	123	101	167	170	233
I	3,197	10,374	5,077	6,237	3,604	2,852

TABLE B.58

1985

URBAN AREA ACCIDENTS

Vehicle #1 Weight < 3,000 lb
Primary Collision Area: Front
Impact Speed: 21-40 mph

FA	1,042
IA	20,470
F	1,062
I	21,698

Victim Age (Years)	<5	5-14	15-24	25-44	45-64	>64
FA	74	150	123	203	207	284
IA	2,088	6,776	3,316	4,073	2,354	1,863
F	75	153	125	207	211	290
I	2,213	7,182	3,515	4,318	2,495	1,975

TABLE B.59

1985

URBAN AREA ACCIDENTS

Vehicle #1 Weight < 3,000 lb
Primary Collision Area: Front
Impact Speed: >40 mph

FA	216
IA	505
F	220
I	536

Victim Age (Years)	<5	5-14	15-24	25-44	45-64	>64
FA	15	32	25	42	43	59
IA	52	167	82	100	58	46
F	16	32	26	42	44	60
I	55	177	87	106	62	49

TABLE B.60

1985

URBAN AREA ACCIDENTS

Vehicle #1 Weight < 3,000 lb
Primary Collision Area: Side
Impact Speed: 0-20 mph

FA	0
IA	2,947
F	0
I	3,123

Victim Age (Years)	<5	5-14	15-24	25-44	45-64	>64
FA	0	0	0	0	0	0
IA	301	975	477	587	339	268
F	0	0	0	0	0	0
I	319	1,034	506	621	359	284

TABLE B.61

1985

URBAN AREA ACCIDENTS

Vehicle #1 Weight < 3,000 lb
Primary Collision Area: Side
Impact Speed: 21-40 mph

FA	0
IA	2,040
F	0
I	2,162

Victim Age (Years)

	<5	5-14	15-24	25-44	45-64	>64
FA	0	0	0	0	0	0
IA	208	675	330	406	235	186
F	0	0	0	0	0	0
I	221	716	350	430	248	197

TABLE B.62

1985

URBAN AREA ACCIDENTS

Vehicle #1 Weight < 3,000 lb
Primary Collision Area: Side
Impact Speed: >40 mph

FA	0
IA	50
F	0
I	54

Victim Age (Years)

	<5	5-14	15-24	25-44	45-64	>64
FA	0	0	0	0	0	0
IA	5	16	8	10	6	5
F	0	0	0	0	0	0
I	6	18	9	11	6	5

TABLE B.63

1985

URBAN AREA ACCIDENTS

Vehicle #1 Weight < 3,000 lb
Primary Collision Area: Rear
Impact Speed: 0-20 mph

FA	0
IA	2,987
F	0
I	3,166

Victim Age (Years)

	<5	5-14	15-24	25-44	45-64	>64
FA	0	0	0	0	0	0
IA	305	989	484	594	344	272
F	0	0	0	0	0	0
I	323	1,048	513	630	364	288

TABLE B.64

1985

URBAN AREA ACCIDENTS

Vehicle #1 Weight > 3,000 lb
Primary Collision Area: Front
Impact Speed: 0-20 mph

FA	2,000
IA	88,602
F	2,039
I	93,917

Victim Age (Years)

	<5	5-14	15-24	25-44	45-64	>64
FA	142	288	236	390	398	546
IA	9,037	29,327	14,353	17,632	10,189	8,063
F	144	294	241	398	406	557
I	9,579	31,087	15,215	18,689	10,800	8,546

TABLE B.65

1985

URBAN AREA ACCIDENTS

Vehicle #1 Weight > 3,000 lb
Primary Collision Area: Front
Impact Speed: 21-40 mph

FA	2,485
IA	61,340
F	2,534
I	65,020

Victim Age (Years)

	<5	5-14	15-24	25-44	45-64	>64
FA	176	358	293	485	495	678
IA	6,257	20,303	9,937	12,207	7,054	5,582
F	180	365	299	494	504	692
I	6,632	21,502	10,553	12,939	7,477	5,917

TABLE B.66

1985

URBAN AREA ACCIDENTS

Vehicle #1 Weight > 3,000 lb
Primary Collision Area: Front
Impact Speed: >40 mph

FA	515
IA	1,515
F	525
I	1,605

Victim Age (Years)

	<5	5-14	15-24	25-44	45-64	>64
FA	37	74	61	100	102	141
IA	155	501	245	301	174	138
F	37	76	62	102	104	144
I	164	531	260	319	185	146

TABLE B.67

1985

URBAN AREA ACCIDENTS

Vehicle #1 Weight > 3,000 lb
Primary Collision Area: Side
Impact Speed: 0-20 mph

FA	52
IA	8,120
F	53
I	8,607

Victim Age (Years)

	<5	5-14	15-24	25-44	45-64	>64
FA	4	7	6	10	10	14
IA	828	2,688	1,315	1,616	934	739
F	4	7	6	10	10	15
I	878	2,849	1,394	1,713	990	783

TABLE B.68

1985

URBAN AREA ACCIDENTS

Vehicle #1 Weight > 3,000 lb
Primary Collision Area: Side
Impact Speed: 21-40 mph

FA	64
IA	5,622
F	66
I	5,959

Victim Age (Years)

	<5	5-14	15-24	25-44	45-64	>64
FA	5	9	8	12	13	17
IA	573	1,861	911	1,119	647	512
F	5	10	8	13	13	18
I	608	1,972	965	1,186	685	542

TABLE B.69

1985

URBAN AREA ACCIDENTS

Vehicle #1 Weight > 3,000 lb
Primary Collision Area: Side
Impact Speed: >40 mph

FA	13
IA	139
F	14
I	147

Victim Age (Years)	<5	5-14	15-24	25-44	45-64	>64
FA	1	2	1	2	3	4
IA	14	47	22	27	16	13
F	1	2	2	2	3	4
I	15	49	24	29	17	13

TABLE B.70

1985

URBAN AREA ACCIDENTS

Vehicle #1 Weight > 3,000 lb
Primary Collision Area: Rear
Impact Speed: 0-20 mph

FA	259
IA	10,367
F	264
I	10,988

Victim Age (Years)	<5	5-14	15-24	25-44	45-64	>64
FA	18	37	31	51	52	70
IA	1,057	3,433	1,679	2,063	1,192	943
F	19	38	31	51	53	72
I	1,121	3,636	1,780	2,187	1,264	1,000

TABLE B.71

1985

RURAL AREA ACCIDENTS

Vehicle #1 Weight < 3,000 lb
Primary Collision Area: Front
Impact Speed: 0-20 mph

FA	472
IA	4,597
F	481
I	4,872

Victim Age (Years)	<5	5-14	15-24	25-44	45-64	>64
FA	34	68	56	92	94	129
IA	469	1,521	745	915	529	418
F	34	69	57	94	96	131
I	497	1,613	789	970	560	443

TABLE B.72

1985

RURAL AREA ACCIDENTS

Vehicle #1 Weight < 3,000 lb
Primary Collision Area: Front
Impact Speed: 21-40 mph

FA	586
IA	3,182
F	597
I	3,373

Victim Age (Years)	<5	5-14	15-24	25-44	45-64	>64
FA	42	84	69	114	117	160
IA	325	1,053	515	633	366	290
F	42	86	70	116	119	163
I	344	1,116	546	671	388	307

TABLE B.73

1985

RURAL AREA ACCIDENTS

Vehicle #1 Weight < 3,000 lb
Primary Collision Area: Front
Impact Speed: >40 mph

FA	121
IA	79
F	124
I	83

Victim Age (Years)	<5	5-14	15-24	25-44	45-64	>64
FA	9	17	14	24	24	33
IA	8	26	13	16	9	7
F	9	18	15	24	25	34
I	8	27	13	17	10	8

TABLE B.74

1985

RURAL AREA ACCIDENTS

Vehicle #1 Weight < 3,000 lb
Primary Collision Area: Side
Impact Speed: 0-20 mph

FA	0
IA	412
F	0
I	437

Victim Age (Years)	<5	5-14	15-24	25-44	45-64	>64
FA	0	0	0	0	0	0
IA	42	136	67	82	47	37
F	0	0	0	0	0	0
I	45	145	71	87	50	40

TABLE B.75

1985

RURAL AREA ACCIDENTS

Vehicle #1 Weight < 3,000 lb
Primary Collision Area: Side
Impact Speed: 21-40 mph

FA	0
IA	286
F	0
I	303

Victim Age (Years)

	<5	5-14	15-24	25-44	45-64	>64
FA	0	0	0	0	0	0
IA	29	95	46	57	33	26
F	0	0	0	0	0	0
I	31	100	49	60	35	28

TABLE B.76

1985

RURAL AREA ACCIDENTS

Vehicle #1 Weight < 3,000 lb
Primary Collision Area: Side
Impact Speed: >40 mph

FA	0
IA	7
F	0
I	7

Victim Age (Years)

	<5	5-14	15-24	25-44	45-64	>64
FA	0	0	0	0	0	0
IA	1	2	1	1	1	1
F	0	0	0	0	0	0
I	1	2	1	1	1	1

TABLE B.77

1985

RURAL AREA ACCIDENTS

Vehicle #1 Weight < 3,000 lb
Primary Collision Area: Rear
Impact Speed: 0-20 mph

FA	0
IA	139
F	0
I	148

Victim Age (Years)	<5	5-14	15-24	25-44	45-64	>64
FA	0	0	0	0	0	0
IA	14	45	23	28	16	13
F	0	0	0	0	0	0
I	15	49	24	29	17	13

TABLE B.78

1985

RURAL AREA ACCIDENTS

Vehicle #1 Weight > 3,000 lb
Primary Collision Area: Front
Impact Speed: 0-20 mph

FA	1,155
IA	14,488
F	1,177
I	15,357

Victim Age (Years)	<5	5-14	15-24	25-44	45-64	>64
FA	82	166	136	225	230	315
IA	1,478	4,796	2,347	2,883	1,666	1,318
F	84	169	139	230	234	321
I	1,566	5,083	2,488	3,056	1,766	1,397

TABLE B.79

1985

RURAL AREA ACCIDENTS

Vehicle #1 Weight > 3,000 lb
Primary Collision Area: Front
Impact Speed: 21-40 mph

FA	1,435
IA	10,030
F	1,463
I	10,632

Victim Age (Years)	<5	5-14	15-24	25-44	45-64	>64
FA	102	207	169	280	286	392
IA	1,023	3,320	1,625	1,996	1,153	913
F	104	211	173	285	291	399
I	1,084	3,519	1,722	2,116	1,223	968

TABLE B.80

1985

RURAL AREA ACCIDENTS

Vehicle #1 Weight > 3,000 lb
Primary Collision Area: Front
Impact Speed: >40 mph

FA	297
IA	248
F	303
I	263

Victim Age (Years)	<5	5-14	15-24	25-44	45-64	>64
FA	21	43	35	58	59	81
IA	25	82	40	49	29	23
F	22	44	36	59	60	83
I	27	87	43	52	30	24

TABLE B.81

1985

RURAL AREA ACCIDENTS

Vehicle #1 Weight > 3,000 lb
Primary Collision Area: Side
Impact Speed: 0-20 mph

FA	0
IA	1,942
F	0
I	2,058

Victim Age (Years)	<5	5-14	15-24	25-44	45-64	>64
FA	0	0	0	0	0	0
IA	198	643	315	386	223	177
F	0	0	0	0	0	0
I	210	681	333	410	237	187

TABLE B.82

1985

RURAL AREA ACCIDENTS

Vehicle #1 Weight > 3,000 lb
Primary Collision Area: Side
Impact Speed: 21-40 mph

FA	0
IA	1,344
F	0
I	1,425

Victim Age (Years)	<5	5-14	15-24	25-44	45-64	>64
FA	0	0	0	0	0	0
IA	137	445	218	267	155	122
F	0	0	0	0	0	0
I	145	472	231	284	164	130

TABLE B.83

1985

RURAL AREA ACCIDENTS

Vehicle #1 Weight > 3,000 lb
Primary Collision Area: Side
Impact Speed: >40 mph

FA	0
IA	33
F	0
I	35

Victim Age (Years)	<5	5-14	15-24	25-44	45-64	>64
FA	0	0	0	0	0	0
IA	3	11	5	6	4	3
F	0	0	0	0	0	0
I	4	12	5	6	4	3

TABLE B.84

1985

RURAL AREA ACCIDENTS

Vehicle #1 Weight > 3,000 lb
Primary Collision Area: Rear
Impact Speed: 0-20 mph

FA	214
IA	1,065
F	218
I	1,129

Victim Age (Years)	<5	5-14	15-24	25-44	45-64	>64
FA	15	31	25	42	43	58
IA	109	353	173	212	122	97
F	15	31	26	43	43	60
I	115	373	183	225	130	103

APPENDIX C-1

1972 and 1985

MOTOR VEHICLE COLLISIONS WITH FIXED OBJECTS ON ROAD

FATAL ACCIDENTS: FA

INJURY ACCIDENTS: IA

PROPERTY DAMAGE ACCIDENTS: PDA

FATALITIES: F

INJURIES: I

TABLE C.1.1

1972
URBAN AREA ACCIDENTS
BY VEHICLE WEIGHT AND PRIMARY DAMAGE AREA

FA	1,667
IA	91,685
PDA	248,364
F	1,900
I	122,858

Vehicle Weight < 3000 lb

FA	417
IA	22,555
PDA	47,438
F	475
I	23,466

	Front	Side	Rear
FA	417	0	0
IA	19,239	2,233	1,083
PDA	35,152	4,744	7,542
F	475	0	0
I	20,016	2,324	1,126

Vehicle Weight > 3000 lb

FA	1,250
IA	69,130
PDA	200,926
F	1,425
I	99,392

	Front	Side	Rear
FA	1,250	0	0
IA	61,941	4,493	2,696
PDA	142,256	15,471	43,199
F	1,425	0	0
I	89,055	6,461	3,876

TABLE C.1.2

1972
RURAL AREA ACCIDENTS
BY VEHICLE WEIGHT AND PRIMARY DAMAGE AREA

FA	2,213
IA	121,715
PDA	192,780
F	2,700
I	183,790

Vehicle Weight < 3000 lb

FA	982
IA	29,942
PDA	46,267
F	1,199
I	35,104

Vehicle Weight > 3000 lb

FA	1,231
IA	91,773
PDA	146,513
F	1,501
I	148,686

	Vehicle Weight < 3000 lb			Vehicle Weight > 3000 lb		
	Front	Side	Rear	Front	Side	Rear
FA	614	307	61	912	319	0
IA	24,133	4,162	1,647	77,181	10,003	4,589
PDA	34,839	5,274	6,154	109,006	16,263	21;244
F	749	375	75	1,112	389	0
I	28,294	4,879	1,931	125,045	16,207	7,434

TABLE C.1.3

1972
URBAN AREA ACCIDENTS
VEHICLE WEIGHT < 3000 lb
PRIMARY DAMAGE AREA: FRONT

FA	417
IA	19,239
PDA	35,152
F	475
I	20,016

Impact Speed:	0-20 MPH	21-40	41-60	>60
FA	20	152	170	75
IA	6,407	9,215	3,098	519
PDA	22,849	9,807	1,969	527
F	23	173	194	85
I	6,665	9,588	3,223	540

TABLE C.1.4

1972
URBAN AREA ACCIDENTS
VEHICLE WEIGHT < 3000 lb
PRIMARY DAMAGE AREA: SIDE

FA	0
IA	2,233
PDA	4,744
F	0
I	2,324

Impact Speed:	0-20 MPH	21-40	41-60	>60
FA	0	0	0	0
IA	1,160	782	248	45
PDA	3,212	1,243	242	47
F	0	0	0	0
I	1,206	813	258	46

TABLE C.1.5

1972
URBAN AREA ACCIDENTS
VEHICLE WEIGHT < 3000 lb
PRIMARY DAMAGE AREA: REAR

FA	0
IA	1,083
PDA	7,542
F	0
I	1,126

Impact Speed:	0-20 MPH	21-40	41-60	>60
FA	0	0	0	0
IA	861	139	83	0
PDA	6,667	513	272	91
F	0	0	0	0
I	895	144	87	0

TABLE C.1.6

1972
URBAN AREA ACCIDENTS
VEHICLE WEIGHT > 3000 lb
PRIMARY DAMAGE AREA: FRONT

FA	1,250
IA	61,941
PDA	142,256
F	1,425
I	89,055

Impact Speed:	0-20 MPH	21-40	41-60	> 60
FA	61	455	510	224
IA	20,626	29,670	9,973	1,672
PDA	92,466	39,689	7,966	2,134
F	70	519	581	255
I	29,655	42,657	14,338	2,404

TABLE C.1.7

1972
URBAN AREA ACCIDENTS
VEHICLE WEIGHT > 3000 lb
PRIMARY DAMAGE AREA: SIDE

FA	0
IA	4,493
PDA	15,471
F	0
I	6,461

Impact Speed:	0-20 MPH	21-40	41-60	>60
FA	0	0	0	0
IA	2,332	1,573	499	90
PDA	10,474	4,053	789	155
F	0	0	0	0
I	3,353	2,261	717	129

TABLE C.1.8

1972
URBAN AREA ACCIDENTS
VEHICLE WEIGHT > 3000 lb
PRIMARY DAMAGE AREA: REAR

FA	0
IA	2,696
PDA	43,199
F	0
I	3,876

Impact Speed:	0-20 MPH	21-40	41-60	>60
FA	0	0	0	0
IA	2,143	345	208	0
PDA	38,188	2,938	1,555	518
F	0	9	0	0
I	3,081	496	298	0

TABLE C.1.9

1972
RURAL AREA ACCIDENTS
VEHICLE WEIGHT < 3000 lb
PRIMARY DAMAGE AREA: FRONT

FA	614
IA	24,133
PDA	34,839
F	749
I	28,294

Impact Speed:	0-20 MPH	21-40	41-60	>60
FA	30	223	251	110
IA	8,036	11,560	3,885	652
PDA	22,645	9,720	1,951	523
F	37	273	306	134
I	9,422	13,553	4,555	764

TABLE C.1.10

1972
RURAL AREA ACCIDENTS
VEHICLE WEIGHT < 3000 lb
PRIMARY DAMAGE AREA: SIDE

FA	307
IA	4,162
PDA	5,274
F	375
I	4,879

Impact Speed:	0-20 MPH	21-40	41-60	> 60
FA	79	115	77	35
IA	2,160	1,457	462	83
PDA	3,570	1,382	269	53
F	98	140	95	43
I	2,532	1,708	542	98

TABLE C.1.11

1972
RURAL AREA ACCIDENTS
VEHICLE WEIGHT < 3000 lb
PRIMARY DAMAGE AREA: REAR

FA	61
IA	1,647
PDA	6,154
F	75
I	1,931

Impact Speed:	0-20 MPH	21-40	41-60	>60
FA	23	31	8	0
IA	1,309	211	126	0
PDA	5,440	418	222	74
F	28	38	9	0
I	1,535	247	149	0

TABLE C.1.12

1972
RURAL AREA ACCIDENTS
VEHICLE WEIGHT > 3000 lb
PRIMARY DAMAGE AREA: FRONT

FA	912
IA	77,181
PDA	109,006
F	1,112
I	125,045

Impact Speed:	0-20 MPH	21-40	41-60	>60
FA	45	332	372	163
IA	25,701	36,970	12,426	2,084
PDA	70,854	30,413	6,104	1,635
F	54	405	454	199
I	41,640	59,897	20,132	3,376

TABLE C.1.13

1972
RURAL AREA ACCIDENTS
VEHICLE WEIGHT > 3000 lb
PRIMARY DAMAGE AREA: SIDE

FA	319
IA	10,003
PDA	16,263
F	389
I	16,207

Impact Speed:	0-20 MPH	21-40	41-60	>60
FA	83	119	80	36
IA	5,192	3,501	1,110	200
PDA	11,010	4,261	829	163
F	101	145	98	44
I	8,411	5,672	1,799	324

TABLE C.1.14

1972
RURAL AREA ACCIDENTS
VEHICLE WEIGHT > 3000 lb
PRIMARY DAMAGE AREA: REAR

FA	0
IA	4,589
PDA	21,244
F	0
I	7,434

Impact Speed:	0-20 MPH	21-40	41-60	>60
FA	0	0	0	0
IA	3,648	587	353	0
PDA	18,780	1,445	765	255
F	0	0	0	0
I	5,910	952	572	0

TABLE C.1.15

1972
URBAN AREA ACCIDENTS
VEHICLE WEIGHT < 3000 lb
PRIMARY DAMAGE AREA: FRONT
IMPACT SPEED: 0-20 MPH

FA	20
IA	6,407
PDA	22,849
F	23
I	6,665

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	7	7	3	3
IA	2,985	1,420	670	1,325
PDA	7,175	6,310	2,030	7,335
F	8	8	4	3
I	3,105	1,480	700	1,380

TABLE C.1.16

1972
URBAN AREA ACCIDENTS
VEHICLE WEIGHT < 300 lb
PRIMARY DAMAGE AREA: FRONT
IMPACT SPEED: 21-40 MPH

FA	152
IA	9,215
PDA	9,807
F	173
I	9,588

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	50	50	26	26
IA	4,290	2,045	970	1,910
PDA	3,080	2,710	875	3,150
F	57	57	30	29
I	4,470	2,130	1,010	1,985

TABLE C.1.17

1972
URBAN AREA ACCIDENTS
VEHICLE WEIGHT < 3000 lb
PRIMARY DAMAGE AREA: FRONT
IMPACT SPEED: 41-60 MPH

FA	170
IA	3,098
PDA	1,969
F	194
I	3,223

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	56	56	29	29
IA	1,445	690	325	640
PDA	620	540	175	630
F	64	64	33	33
I	1,500	715	340	670

TABLE C.1.18

1972
URBAN AREA ACCIDENTS
VEHICLE WEIGHT < 3000 lb
PRIMARY DAMAGE AREA: FRONT
IMPACT SPEED: >60 MPH

FA	75
IA	519
PDA	527
F	85
I	540

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	25	25	13	12
IA	240	115	55	110
PDA	165	145	45	170
F	28	28	15	14
I	250	120	57	112

TABLE C.1.19

1972
URBAN AREA ACCIDENTS
VEHICLE WEIGHT < 3000 lb
PRIMARY DAMAGE AREA: SIDE
IMPACT SPEED: 0-20 MPH

FA	0
IA	1,160
PDA	3,212
F	0
I	1,206

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	0	0	0	0
IA	429	195	224	312
PDA	908	768	507	1,028
F	0	0	0	0
I	446	203	233	324

TABLE C.1.20

1972
URBAN AREA ACCIDENTS
VEHICLE WEIGHT < 3000 lb
PRIMARY DAMAGE AREA: SIDE
IMPACT SPEED: 21-40 MPH

FA	0
IA	782
PDA	1,243
F	0
I	813

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	0	0	0	0
IA	289	131	151	210
PDA	352	297	196	398
F	0	0	0	0
I	301	137	157	219

TABLE C.1.21

1972
URBAN AREA ACCIDENTS
VEHICLE WEIGHT < 3000 lb
PRIMARY DAMAGE AREA: SIDE
IMPACT SPEED: 41-60 MPH

FA	0
IA	248
PDA	242
F	0
I	258

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	0	0	0	0
IA	92	42	49	67
PDA	68	58	38	77
F	0	0	0	0
I	95	43	50	69

TABLE C.1.22

1972
URBAN AREA ACCIDENTS
VEHICLE WEIGHT < 3000 lb
PRIMARY DAMAGE AREA: SIDE
IMPACT SPEED: >60 MPH

FA	0
IA	45
PDA	47
F	0
I	46

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	0	0	0	0
IA	17	8	9	12
PDA	13	11	7	15
F	0	0	0	0
I	18	8	9	12

TABLE C.1.23

1972
URBAN AREA ACCIDENTS
VEHICLE WEIGHT < 3000 lb
PRIMARY DAMAGE AREA: REAR
IMPACT SPEED: 0-20 MPH

FA	0
IA	861
PDA	6,667
F	0
I	895

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	0	0	0	0
IA	134	269	215	242
PDA	1,040	2,087	1,667	1,873
F	0	0	0	0
I	140	280	224	251

TABLE C.1.24

1972
URBAN AREA ACCIDENTS
VEHICLE WEIGHT < 3000 lb
PRIMARY DAMAGE AREA: REAR
IMPACT SPEED: 21-40 MPH

FA	0
IA	139
PDA	513
F	0
I	144

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	0	0	0	0
IA	22	44	35	39
PDA	80	161	128	144
F	0	0	0	0
I	22	45	36	40

TABLE C.1.25

1972

URBAN AREA ACCIDENTS
VEHICLE WEIGHT < 3000 lb
PRIMARY DAMAGE AREA: REAR
IMPACT SPEED: 41-60 MPH

FA	0
IA	83
PDA	272
F	0
I	87

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	0	0	0	0
IA	13	26	21	23
PDA	42	85	68	76
F	0	0	0	0
I	14	27	22	24

TABLE C.1.26

1972
URBAN AREA ACCIDENTS
VEHICLE WEIGHT < 3000 lb
PRIMARY DAMAGE AREA: REAR
IMPACT SPEED: >60 MPH

FA	0
IA	0
PDA	91
F	0
I	0

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	0	0	0	0
IA	0	0	0	0
PDA	14	28	23	26
F	0	0	0	0
I	0	0	0	0

TABLE C.1.27

1972
URBAN AREA ACCIDENTS
VEHICLE WEIGHT > 3000 lb
PRIMARY DAMAGE AREA: FRONT
IMPACT SPEED: 0-20 MPH

FA	61
IA	20,626
PDA	92,466
F	70
I	29,655

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	20	20	11	10
IA	9,610	4,580	2,165	4,270
PDA	29,030	25,520	8,230	29,680
F	23	23	12	12
I	13,730	6,580	3,115	6,140

TABLE C.1.28

1972
URBAN AREA ACCIDENTS
VEHICLE WEIGHT > 3000 lb
PRIMARY DAMAGE AREA: FRONT
IMPACT SPEED: 21-40 MPH

FA	455
IA	29,670
PDA	39,689
F	519
I	42,657

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	150	150	78	77
IA	13,825	6,585	3,115	6,140
PDA	12,460	10,955	3,530	12,740
F	170	170	89	88
I	19,880	9,470	4,480	8,830

TABLE C.1.29

1972
URBAN AREA ACCIDENTS
VEHICLE WEIGHT > 3000 lb
PRIMARY DAMAGE AREA: FRONT
IMPACT SPEED: 41-60 MPH

FA	510
IA	9,973
PDA	7,966
F	581
I	14,338

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	168	168	87	87
IA	4,650	2,215	1,050	2,065
PDA	2,500	2,200	710	2,560
F	190	190	99	99
I	6,680	3,185	1,505	2,970

TABLE C.1.30

1972
URBAN AREA ACCIDENTS
VEHICLE WEIGHT > 3000 lb
PRIMARY DAMAGE AREA: FRONT
IMPACT SPEED: >60 MPH

FA	224
IA	1,672
PDA	2,134
F	255
I	2,404

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	75	75	38	38
IA	780	370	175	345
PDA	670	600	190	685
F	85	85	45	45
I	1,120	535	250	500

TABLE C.1.31

1972
URBAN AREA ACCIDENTS
VEHICLE WEIGHT > 3000 lb
PRIMARY DAMAGE AREA: SIDE
IMPACT SPEED: 0-20 MPH

FA	0
IA	2,332
PDA	10,474
F	0
I	3,353

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	0	0	0	0
IA	863	392	450	627
PDA	2,964	2,503	1,655	3,352
F	0	0	0	0
I	1,241	563	647	902

TABLE C.1.32

1972
URBAN AREA ACCIDENTS
VEHICLE WEIGHT > 3000 lb
PRIMARY DAMAGE AREA: SIDE
IMPACT SPEED: 21-40 MPH

FA	0
IA	1,573
PDA	4,053
F	0
I	2,261

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	0	0	0	0
IA	582	264	304	423
PDA	1,147	969	640	1,297
F	0	0	0	0
I	837	380	436	608

TABLE C.1.33

1972
URBAN AREA ACCIDENTS
VEHICLE WEIGHT > 3000 lb
PRIMARY DAMAGE AREA: SIDE
IMPACT SPEED: 41-60 MPH

FA	0
IA	499
PDA	789
F	0
I	717

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	0	0	0	0
IA	185	84	96	134
PDA	223	189	125	252
F	0	0	0	0
I	265	120	138	193

TABLE C.1.34

1972
URBAN AREA ACCIDENTS
VEHICLE WEIGHT > 3000 lb
PRIMARY DAMAGE AREA: SIDE
IMPACT SPEED: >60 MPH

FA	0
IA	90
PDA	155
F	0
I	129

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	0	0	0	0
IA	33	15	17	24
PDA	44	37	25	50
F	0	0	0	0
I	48	22	25	35

TABLE C.1.35

1972
URBAN AREA ACCIDENTS
VEHICLE WEIGHT < 3000 lb
PRIMARY DAMAGE AREA: REAR
IMPACT SPEED: 21-40 MPH

FA	0
IA	2,143
PDA	38,188
F	0
I	3,081

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	0	0	0	0
IA	334	670	536	602
PDA	5,957	11,953	9,547	10,731
F	0	0	0	0
I	481	964	770	866

TABLE C.1.36

1972
URBAN AREA ACCIDENTS
VEHICLE WEIGHT > 3000 lb
PRIMARY DAMAGE AREA: REAR
IMPACT SPEED: 21-40 MPH

FA	0
IA	345
PDA	2,938
F	0
I	496

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	0	0	0	0
IA	54	108	86	97
PDA	458	920	735	826
F	0	0	0	0
I	77	155	124	139

TABLE C.1.37

1972
URBAN AREA ACCIDENTS
VEHICLE WEIGHT > 3000 lb
PRIMARY DAMAGE AREA: REAR
IMPACT SPEED: 41-60 MPH

FA	0
IA	208
PDA	1,555
F	0
I	298

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	0	0	0	0
IA	32	65	52	58
PDA	243	487	389	437
F	0	0	0	0
I	46	93	75	84

TABLE C.1.38

1972
URBAN AREA ACCIDENTS
VEHICLE WEIGHT > 3000 lb
PRIMARY DAMAGE AREA: REAR
IMPACT SPEED: >60 MPH

FA	0
IA	0
PDA	518
F	0
I	0

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	0	0	0	0
IA	0	0	0	0
PDA	81	162	130	140
F	0	0	0	0
I	0	0	0	0

TABLE C.1.39

1972
RURAL AREA ACCIDENTS
VEHICLE WEIGHT < 3000 lb
PRIMARY DAMAGE AREA: FRONT
IMPACT SPEED: 0-20 MPH

FA	30
IA	8,036
PDA	22,645
F	37
I	9,422

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	10	10	5	5
IA	3,745	1,785	845	1,665
PDA	7,110	6,250	2,015	7,270
F	12	12	6	6
I	4,390	2,090	990	1,950

TABLE C.1.40

1972
RURAL AREA ACCIDENTS
VEHICLE WEIGHT < 3000 lb
PRIMARY DAMAGE AREA: FRONT
IMPACT SPEED: 21-40 MPH

FA	223
IA	11,560
PDA	9,720
F	273
I	13,553

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	75	75	38	38
IA	5,385	2,565	1,215	2,390
PDA	3,050	2,680	865	3,120
F	90	90	45	45
I	6,315	3,010	1,425	2,805

TABLE C.1.41

1972
RURAL AREA ACCIDENTS
VEHICLE WEIGHT < 3000 lb
PRIMARY DAMAGE AREA: FRONT
IMPACT SPEED: 41-60 MPH

FA	251
IA	3,885
PDA	1,951
F	306
I	4,555

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	83	83	42	42
IA	1,810	860	410	805
PDA	610	540	175	625
F	100	100	52	52
I	2,120	1,010	480	940

TABLE C.1.42

1972
RURAL AREA ACCIDENTS
VEHICLE WEIGHT < 3000 lb
PRIMARY DAMAGE AREA: FRONT
IMPACT SPEED: >60 MPH

FA	110
IA	652
PDA	523
F	134
I	764

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	36	36	18	18
IA	305	145	70	135
PDA	165	145	45	170
F	45	45	23	23
I	355	170	80	160

TABLE C.1.43

1972
RURAL AREA ACCIDENTS
VEHICLE WEIGHT < 3000 lb
PRIMARY DAMAGE AREA: SIDE
IMPACT SPEED: 0-20 MPH

FA	79
IA	2,160
PDA	3,570
F	98
I	2,532

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	26	20	16	17
IA	799	363	417	581
PDA	1,010	853	564	1,142
F	32	24	20	22
I	937	425	489	681

TABLE C.1.44

1972
RURAL AREA ACCIDENTS
VEHICLE WEIGHT < 3000 lb
PRIMARY DAMAGE AREA: SIDE
IMPACT SPEED: 21-40 MPH

FA	115
IA	1,457
PDA	1,382
F	140
I	1,708

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	37	28	24	25
IA	539	245	281	392
PDA	391	330	218	442
F	46	35	29	31
I	631	287	330	460

TABLE C.1.45

1972
RURAL AREA ACCIDENTS
VEHICLE WEIGHT < 3000 lb
PRIMARY DAMAGE AREA: SIDE
IMPACT SPEED: 41-60 MPH

FA	77
IA	462
PDA	269
F	95
I	542

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	25	19	16	17
IA	171	78	89	124
PDA	76	64	43	86
F	31	23	20	21
I	200	91	105	146

TABLE C.1.46

1972
RURAL AREA ACCIDENTS
VEHICLE WEIGHT < 3000 lb
PRIMARY DAMAGE AREA: SIDE
IMPACT SPEED: > 60 MPH

FA	35
IA	83
PDA	53
F	43
I	98

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	11	9	7	8
IA	31	14	16	22
PDA	15	13	8	17
F	14	11	9	10
I	36	16	19	26

TABLE C.1.47

1972
RURAL AREA ACCIDENTS
VEHICLE WEIGHT < 3000 lb
PRIMARY DAMAGE AREA: REAR
IMPACT SPEED: 0-20 MPH

FA	23
IA	1,309
PDA	5,440
F	28
I	1,535

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	4	7	6	6
IA	204	410	327	368
PDA	849	1,703	1,360	1,529
F	4	9	7	8
I	239	480	384	431

TABLE C.1.48

1972
RURAL AREA ACCIDENTS
VEHICLE WEIGHT < 3000 lb
PRIMARY DAMAGE AREA: REAR
IMPACT SPEED: 21-40 MPH

FA	31
IA	211
PDA	418
F	38
I	247

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	5	10	8	9
IA	33	66	53	59
PDA	65	131	105	117
F	6	12	10	11
I	39	77	62	69

TABLE C.1.49

1972
RURAL AREA ACCIDENTS
VEHICLE WEIGHT < 3000 lb
PRIMARY DAMAGE AREA: REAR
IMPACT SPEED: 41-60 MPH

FA	8
IA	126
PDA	222
F	9
I	149

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	1	3	2	2
IA	20	39	32	35
PDA	35	69	56	62
F	2	3	2	2
I	23	47	37	42

TABLE C.1.50

1972
RURAL AREA ACCIDENTS
VEHICLE WEIGHT < 3000 lb
PRIMARY DAMAGE AREA: REAR
IMPACT SPEED: >60 MPH

FA	0
IA	0
PDA	74
F	0
I	0

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	0	0	0	0
IA	0	0	0	0
PDA	12	23	19	21
F	0	0	0	0
I	0	0	0	0

TABLE C.1.51

1972
RURAL AREA ACCIDENTS
VEHICLE WEIGHT > 3000 lb
PRIMARY DAMAGE AREA: FRONT
IMPACT SPEED: 0-20 MPH

FA	45
IA	25,701
PDA	70,854
F	54
I	41,640

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	15	15	8	7
IA	11,975	5,705	2,700	5,320
PDA	22,250	19,555	6,305	22,745
F	18	18	9	9
I	19,405	9,245	4,370	8,620

TABLE C.1.52

1972
RURAL AREA ACCIDENTS
VEHICLE WEIGHT > 3000 lb
PRIMARY DAMAGE AREA: FRONT
IMPACT SPEED: 21-40 MPH

FA	332
IA	36,970
PDA	30,413
F	405
I	59,897

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	110	110	56	56
IA	17,230	8,205	3,880	7,650
PDA	9,550	8,395	2,705	9,760
F	134	134	69	69
I	27,910	13,300	6,185	12,400

TABLE C.1.53

1972

RURAL AREA ACCIDENTS

Vehicle Weight: > 3000 lb

Primary Damage Area: Front

Impact Speed: 41-60 MPH

FA	372
IA	12,426
PDA	6,104
F	454
I	20,132

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	123	123	63	63
IA	5,790	2,760	1,305	2,570
PDA	1,915	1,685	545	1,960
F	150	150	77	77
I	9,380	4,470	2,115	4,165

TABLE C.1.54

1972

RURAL AREA ACCIDENTS

Vehicle Weight: > 3000 lb

Primary Damage Area: Front

Impact Speed: > 60 MPH

FA	163
IA	2,084
PDA	1,635
F	199
I	3,376

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	54	54	28	28
IA	970	460	220	430
PDA	515	450	145	525
F	66	66	34	34
I	1,575	750	355	700

TABLE C.1.55

1972

RURAL AREA ACCIDENTS

Vehicle Weight: > 3000 lb

Primary Damage Area: Side

Impact Speed: 0-20 MPH

FA	83
IA	5,192
PDA	11,010
F	101
I	8,411

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	27	21	17	18
IA	1,921	872	1,002	1,396
PDA	3,115	2,631	1,740	3,523
F	33	25	21	22
I	3,112	1,413	1,623	2,263

TABLE C.1.56

1972

RURAL AREA ACCIDENTS

Vehicle Weight: > 3000 lb

Primary Damage Area: Side

Impact Speed: 21-40 MPH

FA	119
IA	3,501
PDA	4,261
F	145
I	5,672

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	39	29	25	26
IA	1,295	588	676	942
PDA	1,206	1,018	673	1,364
F	47	36	30	32
I	2,098	953	1,095	1,526

TABLE C.1.57

1972

RURAL AREA ACCIDENTS

Vehicle Weight: > 3000 lb

Primary Damage Area: Side

Impact Speed: 41-60 MPH

FA	80
IA	1,110
PDA	829
F	98
I	1,799

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	26	20	17	18
IA	410	186	214	299
PDA	235	198	131	265
F	32	24	20	22
I	666	302	347	484

TABLE C.1.58

1972

RURAL AREA ACCIDENTS

Vehicle Weight: > 3000 lb

Primary Damage Area: Side

Impact Speed: > 60 MPH

FA	36
IA	200
PDA	163
F	44
I	324

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	12	9	7	8
IA	74	34	39	54
PDA	46	39	26	52
F	14	11	9	10
I	120	54	62	87

TABLE C.1.59

1972

RURAL AREA ACCIDENTS

Vehicle Weight: > 3000 lb

Primary Damage Area: Rear

Impact Speed: 0-20 MPH

FA	0
IA	3,648
PDA	18,780
F	0
I	5,910

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	0	0	0	0
IA	569	1,142	912	1,025
PDA	2,930	5,878	4,695	5,277
F	0	0	0	0
I	922	1,850	1,478	1,661

TABLE C.1.60

1972

RURAL AREA ACCIDENTS

Vehicle Weight: > 3000 lb

Primary Damage Area: Rear

Impact Speed: 21-40 MPH

FA	0
IA	587
PDA	1,445
F	0
I	952

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	0	0	0	0
IA	92	184	147	165
PDA	225	452	361	406
F	0	0	0	0
I	149	298	238	268

TABLE C.1.61

1972

RURAL AREA ACCIDENTS

Vehicle Weight: > 3,000 lb

Primary Damage Area: Rear

Impact Speed: 41-60 MPH

FA	0
IA	353
PDA	765
F	0
I	572

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	0	0	0	0
IA	55	110	88	99
PDA	119	239	191	215
F	0	0	0	0
I	89	179	143	161

TABLE C.1.62

1972

RURAL AREA ACCIDENTS

Vehicle Weight: > 3000 lb

Primary Damage Area: Rear

Impact Speed: > 60 MPH

FA	0
IA	0
PDA	255
F	0
I	0

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	0	0	0	0
IA	0	0	0	0
PDA	40	80	64	72
F	0	0	0	0
I	0	0	0	0

TABLE C.1.63

1985

URBAN AREA ACCIDENTS

by Vehicle Weight and Primary Damage Area

FA	2,416
IA	120,447
PDA	313,432
F	2,749
I	161,791

Vehicle Weight < 3000 lb

FA	701
IA	36,134
PDA	68,955
F	797
I	48,537

	Front	Side	Rear
FA	701	0	0
IA	30,822	3,577	1,734
PDA	51,096	6,896	10,963
F	797	0	0
I	41,402	4,805	2,330

Vehicle Weight > 3000 lb

FA	1,715
IA	84,313
PDA	244,477
F	1,952
I	113,254

	Front	Side	Rear
FA	1,715	0	0
IA	75,544	5,480	3,288
PDA	173,090	18,825	52,562
F	1,952	0	0
I	101,476	7,362	4,417

TABLE C.1.64

1985

RURAL AREA ACCIDENTS

by Vehicle Weight and Primary Damage Area

FA	2,415
IA	141,395
PDA	226,969
F	2,978
I	214,466

Vehicle Weight < 3000 lb

FA	1,159
IA	42,419
PDA	61,282
F	1,429
I	64,340

	Front	Side	Rear
FA	724	363	72
IA	34,190	5,896	2,333
PDA	46,145	6,986	8,151
F	893	447	86
I	51,858	8,943	3,539

Vehicle Weight > 3000 lb

FA	1,256
IA	98,976
PDA	165,687
F	1,549
I	150,126

	Front	Side	Rear
FA	931	325	0
IA	83,239	10,788	4,949
PDA	123,271	18,391	24,025
F	1,147	402	0
I	126,256	16,364	7,506

TABLE C.1.65

1985

URBAN AREA ACCIDENTS

Vehicle Weight: < 3000 lb

Primary Damage Area: Front

FA	701
IA	30,822
PDA	51,096
F	797
I	41,402

Impact Speed:	0-20 MPH	21-40	41-60	>60
FA	34	255	286	125
IA	10,264	14,764	4,962	832
PDA	33,212	14,256	2,861	766
F	39	290	325	143
I	13,787	19,831	6,666	1,118

TABLE C.1.66

1985

URBAN AREA ACCIDENTS

Vehicle Weight: < 3,000 lb

Primary Damage Area: Side

FA	0
IA	3,577
PDA	6,896
F	0
I	4,805

Impact Speed:	0-20 MPH	21-40	41-60	>60
FA	0	0	0	0
IA	1,856	1,252	397	72
PDA	4,669	1,807	352	69
F	0	0	0	0
I	2,494	1,682	533	96

TABLE C.1.67

1985

URBAN AREA ACCIDENTS

Vehicle Weight: < 3000 lb

Primary Damage Area: Rear

FA	0
IA	1,734
PDA	10,963
F	0
I	2,330

Impact Speed:	0-20 MPH	21-40	41-60	>60
FA	0	0	0	0
IA	1,379	222	134	0
PDA	9,691	745	395	132
F	0	0	0	0
I	1,852	298	179	0

TABLE C.1.68

1985

URBAN AREA ACCIDENTS

Vehicle Weight: > 3000 lb

Primary Damage Area: Front

FA	1,715
IA	75,544
PDA	173,090
F	1,952
I	101,476

Impact Speed:	0-20 MPH	21-40	41-60	> 60
FA	84	624	700	307
IA	25,156	36,186	12,163	2,040
PDA	112,509	48,292	9,693	2,596
F	96	710	796	349
I	33,792	48,607	16,337	2,740

TABLE C.1.69

1985

URBAN AREA ACCIDENTS

Vehicle Weight: > 3000 lb

Primary Damage Area: Side

FA	0
IA	5,480
PDA	18,825
F	0
I	7,362

Impact Speed:	0-20 MPH	21-40	41-60	>60
FA	0	0	0	0
IA	2,844	1,918	608	110
PDA	12,745	4,932	960	188
F	0	0	0	0
I	3,821	2,577	817	147

TABLE C.1.70

1985

URBAN AREA ACCIDENTS

Vehicle Weight: > 3000 lb

Primary Damage Area: Rear

FA	0
IA	3,288
PDA	52,562
F	0
I	4,417

Impact Speed:	0-20 MPH	21-40	41-60	>60
FA	0	0	0	0
IA	2,614	421	253	0
PDA	46,464	3,574	1,892	630
F	0	0	0	0
I	3,512	565	340	0

TABLE C.1.71

1985

URBAN AREA ACCIDENTS

Vehicle Weight: < 3000 lb

Primary Damage Area: Front

FA	724
IA	34,190
PDA	46,145
F	893
I	51,858

Impact Speed:	0-20 MPH	21-40	41-60	>60
FA	35	264	295	130
IA	11,385	16,377	5,505	923
PDA	29,994	12,874	2,584	692
F	44	325	364	160
I	17,269	24,840	8,349	1,400

TABLE C.1.72

URBAN AREA ACCIDENTS

Vehicle Weight: < 3000 lb

Primary Damage Area: Side

FA	363
IA	5,896
PDA	6,986
F	447
I	8,943

Impact Speed:	0-20 MPH	21-40	41-60	> 60
FA	94	136	91	41
IA	3,060	2,063	654	118
PDA	4,730	1,830	356	70
F	116	167	113	51
I	4,641	3,130	993	179

TABLE C.1.73

1985

RURAL AREA ACCIDENTS

Vehicle Weight: < 3000 lb

Primary Damage Area: Rear

FA	72
IA	2,333
PDA	8,151
F	86
I	3,539

Impact Speed:	0-20 MPH	21-40	41-60	>60
FA	27	36	9	0
IA	1,855	299	180	0
PDA	7,205	554	293	98
F	32	43	11	0
I	2,814	453	273	0

TABLE C.1.74

1985

RURAL AREA ACCIDENTS

Vehicle Weight: > 3000 lb

Primary Damage Area: Front

FA	931
IA	83,239
PDA	123,271
F	1,147
I	126,256

Impact Speed:	0-20 MPH	21-40	41-60	> 60
FA	46	338	380	167
IA	27,719	39,871	13,401	2,247
PDA	80,126	34,393	6,903	1,849
F	56	418	468	205
I	42,043	60,477	20,327	3,409

TABLE C.1.75

1985

RURAL AREA ACCIDENTS

Vehicle Weight: > 3000 lb

Primary Damage Area: Side

FA	325
IA	10,788
PDA	18,391
F	402
I	16,364

Impact Speed:	0-20 MPH	21-40	41-60	>60
FA	85	122	82	37
IA	5,599	3,776	1,197	216
PDA	12,450	4,818	938	184
F	105	150	101	46
I	8,493	5,727	1,816	327

TABLE C.1.76

1985

RURAL AREA ACCIDENTS

Vehicle Weight: > 3000 lb

Primary Damage Area: Rear

FA	0
IA	4,949
PDA	24,025
F	0
I	7,506

Impact Speed:	0-20 MPH	21-40	41-60	>60
FA	0	0	0	0
IA	3,934	633	381	0
PDA	21,238	1,634	865	288
F	0	0	0	0
I	5,967	961	578	0

TABLE C.1.77

1985

URBAN AREA ACCIDENTS

Vehicle Weight: < 3000 lb

Primary Damage Area: Front

Impact Speed: 0-20 MPH

FA	34
IA	10,264
PDA	33,212
F	39
I	13,787

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	11	11	6	6
IA	4,783	2,279	1,078	2,125
PDA	10,429	9,167	2,956	10,661
F	13	13	6	6
I	6,425	3,061	1,448	2,854

TABLE C.1.78

1985

URBAN AREA ACCIDENTS

Vehicle Weight: < 3000 lb

Primary Damage Area: Front

Impact Speed: 21-40 MPH

FA	255
IA	14,764
PDA	14,256
F	290
I	19,831

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	84	84	43	43
IA	6,880	3,278	1,550	3,056
PDA	4,476	3,935	1,269	4,576
F	96	96	49	49
I	9,241	4,402	2,082	4,105

TABLE C.1.79

1985

URBAN AREA ACCIDENTS

Vehicle Weight: < 3000 lb

Primary Damage Area: Front

Impact Speed: 41-50 MPH

FA	286
IA	4,962
PDA	2,861
F	325
I	6,666

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	94	94	49	49
IA	2,312	1,101	521	1,027
PDA	898	790	255	918
F	107	101	55	55
I	3,106	1,480	700	1,380

TABLE C.1.80

URBAN AREA ACCIDENTS

Vehicle Weight: < 3000 lb

Primary Damage Area: Front

Impact Speed: > 60 MPH

FA	125
IA	832
PDA	766
F	143
I	1,118

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	41	41	21	21
IA	388	185	87	172
PDA	241	211	68	246
F	47	47	24	24
I	521	248	117	231

TABLE C.1.81

1985

URBAN AREA ACCIDENTS

Vehicle Weight: < 3000 lb

Primary Damage Area: Side

Impact Speed: 0-20 MPH

FA	0
IA	1,856
PDA	4,669
F	0
I	2,494

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	0	0	0	0
IA	687	312	358	499
PDA	1,321	1,116	738	1,494
F	0	0	0	0
I	923	419	481	671

TABLE C.1.82

1985

URBAN AREA ACCIDENTS

Vehicle Weight: < 3000 lb

Primary Damage Area: Side

Impact Speed: 21-40 MPH

FA	0
IA	1,252
PDA	1,807
F	0
I	1,682

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	0	0	0	0
IA	463	210	242	337
PDA	511	432	286	578
F	0	0	0	0
I	622	283	325	452

TABLE C.1.83

1985

URBAN AREA ACCIDENTS

Vehicle Weight: < 3000 lb

Primary Damage Area: Side

Impact Speed: 41-60 MPH

FA	0
IA	397
PDA	352
F	0
I	533

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	0	0	0	0
IA	147	67	77	107
PDA	100	84	56	113
F	0	0	0	0
I	197	90	103	143

TABLE C.1.84

URBAN AREA ACCIDENTS

Vehicle Weight: < 3000 lb

Primary Damage Area: Aide

Impact Speed: > 60

FA	0
IA	72
PDA	69
F	0
I	96

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	0	0	0	0
IA	27	12	14	19
PDA	20	16	11	22
F	0	0	0	0
I	36	16	19	26

TABLE C.1.85

1985

URBAN AREA ACCIDENTS

Vehicle Weight: < 3000 lb

Primary Damage Area: Rear

Impact Speed: 0-20 MPH

FA	0
IA	1,379
PDA	9,691
F	0
I	1,852

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	0	0	0	0
IA	215	432	345	387
PDA	1,512	3,033	2,423	2,723
F	0	0	0	0
I	289	580	463	520

TABLE C.1.86

1985

URBAN AREA ACCIDENTS

Vehicle Weight: < 3000 lb

Primary Damage Area: Rear

Impact Speed: 21-40 MPH

FA	0
IA	222
PDA	745
F	0
I	298

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	0	0	0	0
IA	35	69	56	62
PDA	116	233	186	209
F	0	0	0	0
I	46	93	75	84

TABLE C.1.87

1985

URBAN AREA ACCIDENTS

Vehicle Weight: < 3000 lb

Primary Damage Area: Rear

Impact Speed: 41-60 MPH

FA	0
IA	134
PDA	395
F	0
I	179

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	0	0	0	0
IA	21	42	34	38
PDA	62	124	99	111
F	0	0	0	0
I	28	56	45	50

TABLE C.1.88

1985

URBAN AREA ACCIDENTS

Vehicle Weight: < 3000 lb

Primary Damage Area: Rear

Impact Speed: > 60

FA	0
IA	0
PDA	132
F	0
I	0

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	0	0	0	0
IA	0	0	0	0
PDA	21	41	33	37
F	0	0	0	0
I	0	0	0	0

TABLE C.1.89

1985

URBAN AREA ACCIDENTS

Vehicle Weight: > 3000 lb

Primary Damage Area: Front

Impact Speed: 0-20 MPH

FA	84
IA	25,156
PDA	112,509
F	96
I	33,792

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	28	28	14	14
IA	11,722	5,585	2,641	5,207
PDA	35,328	31,052	10,013	36,115
F	32	32	16	16
I	15,747	7,501	3,548	6,994

TABLE C.1.90

1985

URBAN AREA ACCIDENTS

Vehicle Weight: > 3000 lb

Primary Damage Area: Front

Impact Speed: 21-40 MPH

FA	624
IA	36,186
PDA	48,292
F	710
I	48,607

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	206	206	106	106
IA	16,863	8,033	3,780	7,491
PDA	15,164	13,329	4,298	15,502
F	234	234	121	121
I	22,651	10,791	5,104	10,062

TABLE C.1.91

1985

URBAN AREA ACCIDENTS

Vehicle Weight > 3,000 lb
Primary Damage Area: Front
Impact Speed: 41-60 mph

FA	700
IA	12,163
PDA	9,693
F	796
I	16,337

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	231	231	119	119
IA	5,668	2,700	1,277	2,518
PDA	3,044	2,675	863	3,111
F	263	263	135	135
I	7,613	3,627	1,715	3,382

TABLE C.1.92

1985

URBAN AREA ACCIDENTS

Vehicle Weight > 3,000 lb
Primary Damage Area: Front
Impact Speed: >60 mph

FA	307
IA	2,040
PDA	2,596
F	349
I	2,740

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	101	101	52	52
IA	951	453	214	422
PDA	815	716	231	833
F	115	115	59	59
I	1,277	608	288	567

TABLE C.1.93

1985

URBAN AREA ACCIDENTS

Vehicle Weight > 3,000 lb
Primary Damage Area: Side
Impact Speed: 0-20 mph

FA	0
IA	2,844
PDA	12,745
F	0
I	3,821

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	0	0	0	0
IA	1,052	478	549	765
PDA	3,607	3,046	2,014	4,078
F	0	0	0	0
I	1,414	642	737	1,028

TABLE C.1.94

1985

URBAN AREA ACCIDENTS

Vehicle Weight > 3,000 lb
Primary Damage Area: Side
Impact Speed: 21-40 mph

FA	0
IA	1,918
PDA	4,932
F	0
I	2,577

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	0	0	0	0
IA	710	322	370	516
PDA	1,396	1,179	779	1,578
F	0	0	0	0
I	953	433	497	693

TABLE C.1.95

1985

URBAN AREA ACCIDENTS

Vehicle Weight > 3,000 lb
Primary Damage Area: Side
Impact Speed: 41-60 mph

FA	0
IA	608
PDA	960
F	0
I	817

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	0	0	0	0
IA	225	102	117	164
PDA	272	229	152	307
F	0	0	0	0
I	302	137	158	220

TABLE C.1.96

1985

URBAN AREA ACCIDENTS

Vehicle Weight > 3,000 lb
Primary Damage Area: Side
Impact Speed: >60 mph

FA	0
IA	110
PDA	188
F	0
I	147

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	0	0	0	0
IA	41	18	21	30
PDA	53	45	30	60
F	0	0	0	0
I	54	25	28	40

TABLE C.1.97

1985

URBAN AREA ACCIDENTS

Vehicle Weight > 3,000 lb
Primary Damage Area: Rear
Impact Speed: 0-20 mph

FA	0
IA	2,614
PDA	46,464
F	0
I	3,512

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	0	0	0	0
IA	408	818	654	735
PDA	7,248	14,543	11,616	13,056
F	0	0	0	0
I	548	1,099	878	987

TABLE C.1.98

1985

URBAN AREA ACCIDENTS

Vehicle Weight > 3,000 lb
Primary Damage Area: Rear
Impact Speed: 21-40 mph

FA	0
IA	421
PDA	3,574
F	0
I	565

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	0	0	0	0
IA	66	132	105	118
PDA	558	1,119	894	1,004
F	0	0	0	0
I	88	177	141	159

TABLE C.1.99

1985

URBAN AREA ACCIDENTS

Vehicle Weight > 3,000 lb
Primary Damage Area: Rear
Impact Speed: 41-60 mph

FA	0
IA	253
PDA	1,892
F	0
I	340

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	0	0	0	0
IA	39	79	63	71
PDA	295	592	473	532
F	0	0	0	0
I	53	106	85	96

TABLE C.1.100

1985

URBAN AREA ACCIDENTS

Vehicle Weight > 3,000 lb
Primary Damage Area: Rear
Impact Speed: >60 mph

FA	0
IA	0
PDA	630
F	0
I	0

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	0	0	0	0
IA	0	0	0	0
PDA	98	197	158	177
F	0	0	0	0
I	0	0	0	0

TABLE C.1.101

1985

RURAL AREA ACCIDENTS

Vehicle Weight < 3,000 lb
Primary Damage Area: Front
Impact Speed: 0-20 mph

FA	35
IA	11,385
PDA	29,994
F	44
I	17,269

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	12	12	6	6
IA	5,305	2,527	1,195	2,357
PDA	9,418	8,278	2,669	9,628
F	15	15	7	7
I	8,047	3,833	1,813	3,575

TABLE C.1.102

1985

RURAL AREA ACCIDENTS

Vehicle Weight < 3,000 lb
Primary Damage Area: Front
Impact Speed: 0-20 mph

FA	264
IA	16,377
PDA	12,874
F	325
I	24,840

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	87	87	45	45
IA	7,632	3,636	1,720	3,390
PDA	4,042	3,553	1,146	4,133
F	107	107	55	55
I	11,575	5,514	2,608	5,142

TABLE C.1.103

1985

RURAL AREA ACCIDENTS

Vehicle Weight < 3,000 lb
Primary Damage Area: Front
Impact Speed: 41-60 mph

FA	295
IA	5,505
PDA	2,584
F	364
I	8,349

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	97	97	50	50
IA	2,565	1,222	578	1,140
PDA	811	713	230	829
F	120	120	62	62
I	3,891	1,853	877	1,728

TABLE C.1.104

1985

RURAL AREA ACCIDENTS

Vehicle Weight < 3,000 lb
Primary Damage Area: Front
Impact Speed: >60 mph

FA	130
IA	923
PDA	692
F	160
I	1,400

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	43	43	22	22
IA	430	205	[illegible]	191
PDA	217	191	[illegible]	222
F	53	53	[illegible]	27
I	652	311	[illegible]	290

TABLE C.1.105

1985

RURAL AREA ACCIDENTS

Vehicle Weight: < 3000 lb

Primary Damage Area: Side

Impact Speed: 0-20 MPH

FA	94
IA	3,060
PDA	4,730
F	116
I	4,641

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	31	23	20	21
IA	1,132	514	590	823
PDA	1,339	1,130	747	1,514
F	38	29	24	26
I	1,717	780	896	1,248

TABLE C.1.106

RURAL AREA ACCIDENTS

Vehicle Weight: < 3000 lb

Primary Damage Area: Side

Impact Speed: 21-40 MPH

FA	136
IA	2,063
PDA	1,830
F	167
I	3,130

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	44	34	28	30
IA	763	347	398	555
PDA	518	437	289	586
F	54	41	35	37
I	1,158	526	604	842

TABLE C.1.107

1985

RURAL AREA ACCIDENTS

Vehicle Weight: < 3000 lb

Primary Damage Area: Side

Impact Speed: 41-60 MPH

FA	91
IA	654
PDA	356
F	113
I	993

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	30	22	19	20
IA	242	110	126	176
PDA	101	85	56	114
F	37	28	24	25
I	367	167	192	267

TABLE C.1.108

1985

RURAL AREA ACCIDENTS

Vehicle Weight: < 3000 lb

Primary Damage Area: Side

Impact Speed: > 60 MPH

FA	41
IA	118
PDA	70
F	51
I	179

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	13	10	9	9
IA	44	20	23	32
PDA	20	17	11	22
F	17	13	11	11
I	66	30	35	48

TABLE C.1.109

1985

RURAL AREA ACCIDENTS

Vehicle Weight: < 3000 lb

Primary Damage Area: Rear

Impact Speed: 0-20 MPH

FA	27
IA	1,855
PDA	7,205
F	32
I	2,814

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	4	8	7	8
IA	289	581	464	521
PDA	1,124	2,255	1,801	2,025
F	5	10	8	9
I	439	881	704	791

TABLE C.1.110

1985

RURAL AREA ACCIDENTS

Vehicle Weight: < 3000 lb

Primary Damage Area: Rear

Impact Speed: 21-40 MPH

FA	36
IA	299
PDA	554
F	43
I	453

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	6	11	9	10
IA	47	94	75	84
PDA	86	173	139	156
F	7	13	11	12
I	71	142	113	127

TABLE C.1.111

1985

RURAL AREA ACCIDENTS

Vehicle Weight: < 3000 lb

Primary Damage Area: Rear

Impact Speed: 41-60 MPH

FA	9
IA	180
PDA	293
F	11
I	273

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	1	3	2	3
IA	28	56	45	51
PDA	46	92	73	82
F	2	3	3	3
I	43	85	68	77

TABLE C.1.112

1985

RURAL AREA ACCIDENTS

Vehicle Weight: < 3000 lb

Primary Damage Area: Rear

Impact Speed: > 60 MPH

FA	0
IA	0
PDA	98
F	0
I	0

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	0	0	0	0
IA	0	0	0	0
PDA	15	31	25	28
F	0	0	0	0
I	0	0	0	0

TABLE C.1.113

1985

RURAL AREA ACCIDENTS

Vehicle Weight: > 3000 lb

Primary Damage Area: Front

Impact Speed: 0-20 MPH

FA	46
IA	27,719
PDA	80,126
F	56
I	42,043

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	15	15	8	8
IA	12,917	6,154	2,910	5,738
PDA	25,160	22,115	7,131	25,720
F	18	18	10	10
I	19,592	9,333	4,415	8,702

TABLE C.1.114

1985

RURAL AREA ACCIDENTS

Vehicle Weight: > 3000 lb

Primary Damage Area: Front

Impact Speed: 21-40 MPH

FA	338
IA	39,871
PDA	34,393
F	418
I	60,477

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	112	112	57	57
IA	18,580	8,851	4,186	8,253
PDA	10,799	9,492	3,061	11,040
F	138	138	71	71
I	28,182	13,425	6,350	12,519

TABLE C.1.115

1985

RURAL AREA ACCIDENTS

Vehicle Weight: > 3000 lb

Primary Damage Area: Front

Impact Speed: 41-60 MPH

FA	380
IA	13,401
PDA	6,903
F	468
I	20,327

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	125	125	65	65
IA	6,245	2,975	1,407	2,774
PDA	2,168	1,905	614	2,216
F	154	154	80	80
I	9,472	4,512	2,134	4,208

TABLE C.1.116

1985

RURAL AREA ACCIDENTS

Vehicle Weight: > 3000 lb

Primary Damage Area: Front

Impact Speed: > 60 MPH

FA	167
IA	2,247
PDA	1,849
F	205
I	3,409

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	55	55	28	28
IA	1,047	499	236	465
PDA	581	510	165	594
F	68	68	35	35
I	1,589	757	358	706

TABLE C.1.117

1985

RURAL AREA ACCIDENTS

Vehicle Weight: > 3000 lb

Primary Damage Area: Side

Impact Speed: 0-20 MPH

FA	85
IA	5,599
PDA	12,450
F	105
I	8,493

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	28	21	18	19
IA	2,072	941	1,081	1,506
PDA	3,523	2,976	1,967	3,984
F	34	26	22	23
I	3,142	1,427	1,639	2,285

TABLE C.1.118

1985

RURAL AREA ACCIDENTS

Vehicle Weight: > 3000 lb

Primary Damage Area: Side

Impact Speed: 21-40 MPH

FA	122
IA	3,776
PDA	4,818
F	150
I	5,727

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	40	30	25	27
IA	1,397	634	729	1,016
PDA	1,363	1,152	761	1,542
F	49	37	31	33
I	2,119	962	1,105	1,540

TABLE C.1.119

1985

RURAL AREA ACCIDENTS

Vehicle Weight: > 3000 lb

Primary Damage Area: Side

Impact Speed: 41-60 MPH

FA	82
IA	1,197
PDA	938
F	101
I	1,816

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	27	20	17	18
IA	443	201	231	322
PDA	265	224	148	300
F	33	25	21	22
I	672	305	350	488

TABLE C.1.120

1985

RURAL AREA ACCIDENTS

Vehicle Weight: > 3000 lb

Primary Damage Area: Side

Impact Speed: > 60 MPH

FA	37
IA	216
PDA	184
F	46
I	327

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	12	9	8	8
IA	80	36	42	58
PDA	52	44	29	59
F	15	11	10	10
I	121	55	63	88

TABLE C.1.121

1985

RURAL AREA ACCIDENTS

Vehicle Weight: > 3000 lb

Primary Damage Area: Rear

Impact Speed: 0-20 MPH

FA	0
IA	3,934
PDA	21,238
F	0
I	5,967

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	0	0	0	0
IA	614	1,231	984	1,105
PDA	3,313	6,647	5,310	5,968
F	0	0	0	0
I	931	1,868	1,492	1,677

TABLE C.1.122

1985

RURAL AREA ACCIDENTS

Vehicle Weight: > 3000 lb

Primary Damage Area: Rear

Impact Speed: 21-40 MPH

FA	0
IA	633
PDA	1,634
F	0
I	961

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	0	0	0	0
IA	99	198	158	178
PDA	255	511	409	459
F	0	0	0	0
I	150	301	240	270

TABLE C.1.123

1985

RURAL AREA ACCIDENTS

Vehicle Weight: > 3000 lb

Primary Damage Area: Rear

Impact Speed: 41-60 MPH

FA	0
IA	381
PDA	865
F	0
I	578

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	0	0	0	0
IA	59	119	95	107
PDA	135	271	216	243
F	0	0	0	0
I	90	181	145	162

TABLE C.1.124

1985

RURAL AREA ACCIDENTS

Vehicle Weight: > 3000 lb

Primary Damage Area: Rear

Impact Speed: > 60 MPH

FA	0
IA	0
PDA	288
F	0
I	0

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA	0	0	0	0
IA	0	0	0	0
PDA	45	90	72	81
F	0	0	0	0
I	0	0	0	0

APPENDIX C.2

1972 and 1985

MOTOR VEHICLE COLLISIONS WITH FIXED OBJECTS--OFF ROAD

FATAL ACCIDENTS:	FA
INJURY ACCIDENTS:	IA
PROPERTY DAMAGE ACCIDENTS:	PDA
FATALITIES:	F
INJURIES:	I

TABLE C.2.1

1972

Total

FA	6,835
IA	116,245
PDA	79,410
F	7,575
I	174,370

Urban

FA	1,260
IA	37,870
PDA	21,070
F	1,370
I	53,020

Day		Night	
FA	210	FA	1,050
IA	13,030	IA	24,840
PDA	9,020	PDA	12,050
F	260	F	1,110
I	18,240	I	34,780

Dry		Wet	
FA	1,020	FA	240
IA	23,180	IA	14,690
PDA	12,180	PDA	8,890
F	1,110	F	260
I	32,450	I	20,570

Rural

FA	5,575
IA	78,375
PDA	58,340
F	6,205
I	121,350

Day		Night	
FA	1,060	FA	4,515
IA	27,740	IA	50,635
PDA	23,860	PDA	34,480
F	1,690	F	4,515
I	42,960	I	78,390

Dry		Wet	
FA	4,020	FA	1,555
IA	42,480	IA	35,895
PDA	27,830	PDA	30,510
F	4,470	F	1,735
I	65,770	I	55,580

TABLE C.2.2

1972

URBAN AREA ACCIDENTS BY VEHICLE WEIGHT AND PRIMARY DAMAGE AREA

FA	1,260
IA	37,870
PDA	21,070
F	1,370
I	53,020

Vehicle Weight < 3,000 lb

FA	315
IA	9,316
PDA	4,025
F	342
I	10,127

Vehicle Weight > 3,000 lb

FA	945
IA	28,553
PDA	17,047
F	1,028
I	42,894

	< 3,000 lb Front	< 3,000 lb Side	< 3,000 lb Rear	> 3,000 lb Front	> 3,000 lb Side	> 3,000 lb Rear
FA	315	0	0	945	0	0
IA	7,946	922	447	25,584	1,856	1,114
PDA	2,982	402	640	12,069	1,313	3,665
F	342	0	0	1,028	0	0
I	8,638	1,003	486	38,433	2,788	1,673

TABLE C.2.3

1972

RURAL AREA ACCIDENTS BY VEHICLE WEIGHT AND PRIMARY DAMAGE AREA

FA	5,575
IA	78,375
PDA	58,340
F	6,205
I	121,350

	Vehicle Weight < 3,000 lb	Vehicle Weight > 3,000 lb
FA	2,474	3,101
IA	19,280	59,094
PDA	14,001	44,338
F	2,755	3,450
I	23,178	98,172

	Vehicle Weight < 3,000 lb			Vehicle Weight > 3,000 lb		
	Front	Side	Rear	Front	Side	Rear
FA	1,547	773	154	2,298	804	0
IA	15,540	2,680	1,061	49,698	6,441	2,955
PDA	10,543	1,596	1,862	32,987	4,922	6,429
F	1,721	862	172	2,556	894	0
I	18,681	3,221	1,275	82,562	10,701	4,908

TABLE C.2.4

1985

Total

FA	8,500
IA	142,600
PDA	97,300
F	9,430
I	213,950

Urban

FA	1,560
IA	46,430
PDA	25,830
F	1,705
I	65,050

Day		Night	
FA	260	FA	1,300
IA	15,970	IA	30,460
PDA	11,060	PDA	14,770
F	320	F	1,385
I	22,380	I	42,670

Dry		Wet	
FA	1,260	FA	300
IA	28,415	IA	18,015
PDA	14,930	PDA	10,900
F	1,390	F	315
I	39,810	I	25,240

Rural

FA	6,940
IA	96,170
PDA	71,470
F	7,725
I	148,900

Day		Night	
FA	1,325	FA	5,615
IA	34,040	IA	62,130
PDA	29,230	PDA	42,240
F	1,800	F	5,925
I	52,710	I	96,190

Dry		Wet	
FA	5,000	FA	1,940
IA	52,120	IA	44,050
PDA	34,090	PDA	37,380
F	5,570	F	2,155
I	80,700	I	68,200

TABLE C.2.5

1985

URBAN AREA ACCIDENTS BY VEHICLE WEIGHT AND PRIMARY DAMAGE AREA

FA	1,560
IA	46,430
PDA	25,830
F	1,705
I	65,050

Vehicle Weight < 3,000 lb

FA	390
IA	11,410
PDA	4,940
F	426
I	12,420

Vehicle Weight > 3,000 lb

FA	1,170
IA	35,020
PDA	20,890
F	1,279
I	52,630

	Vehicle Weight < 3,000 lb			Vehicle Weight > 3,000 lb		
	Front	Side	Rear	Front	Side	Rear
FA	390	0	0	1,170	0	0
IA	9,740	1,120	550	31,380	2,275	1,365
PDA	3,653	493	798	14,785	1,608	4,490
F	426	0	0	1,279	0	0
I	10,599	1,231	596	47,156	3,421	2,052

TABLE C.2.6

1985

RURAL AREA ACCIDENTS BY VEHICLE WEIGHT AND PRIMARY DAMAGE AREA

FA	6,940
IA	96,170
PDA	71,470
F	7,725
I	148,900

Vehicle Weight < 3,000 lb

FA	3,080
IA	23,660
PDA	17,155
F	3,430
I	28,445

Vehicle Weight > 3,000 lb

FA	3,860
IA	72,510
PDA	54,315
F	4,295
I	120,455

	Vehicle Weight < 3,000 lb			Vehicle Weight > 3,000 lb		
	Front	Side	Rear	Front	Side	Rear
FA	1,926	963	191	2,860	1,000	0
IA	19,067	3,288	1,301	60,980	7,903	3,627
PDA	12,915	1,955	2,285	40,410	6,030	7,875
F	2,143	1,073	215	3,182	1,113	0
I	22,920	3,955	1,570	101,300	13,130	6,025

TABLE C.2.7

1985

FIXED OBJECT--OFF ROAD

URBAN AREA ACCIDENTS

Vehicle Weight < 3,000 lb
Primary Damage Area: Front
Impact Speed: 0-20 mph

FA
IA
PDA
F
I

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA				
IA				
PDA				
F	4	4	2	13
I	617	293	141	2,478

TABLE C.2.8

1985

URBAN AREA ACCIDENTS

Vehicle Weight < 3,000 lb
Primary Damage Area: Front
Impact Speed: 21-40 mph

FA
IA
PDA
F
I

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA				
IA				
PDA				
F	26	26	13	90
I	889	421	203	3,564

TABLE C.2.9

1985

URBAN AREA ACCIDENTS

Vehicle Weight < 3,000 lb
Primary Damage Area: Front
Impact Speed: 41-60 mph

FA
IA
PDA
F
I

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA				
IA				
PDA				
F	30	30	15	101
I	299	142	68	1,198

TABLE C.2.10

URBAN AREA ACCIDENTS

Vehicle Weight < 3,000 lb
Primary Damage Area: Front
Impact Speed: >60 mph

FA
IA
PDA
F
I

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA				
IA				
PDA				
F	13	13	6	44
I	50	24	12	201

TABLE C.2.11

URBAN AREA ACCIDENTS

Vehicle Weight < 3,000 lb
Primary Damage Area: Side
Impact Speed: 0-20 mph

FA
IA
PDA
F
I

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA				
IA				
PDA				
F	0	0	0	0
I	236	107	123	172

TABLE C.2.12

URBAN AREA ACCIDENTS

Vehicle Weight < 3,000 lb
Primary Damage Area: Side
Impact Speed: 21-40 mph

FA
IA
PDA
F
I

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA				
IA				
PDA				
F	0	0	0	0
I	159	73	83	116

TABLE C.2.13

URBAN AREA ACCIDENTS

Vehicle Weight < 3,000 lb
Primary Damage Area: Side
Impact Speed: 41-60 mph

FA
IA
PDA
F
I

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA				
IA				
PDA				
F	0	0	0	0
I	50	23	26	37

TABLE C.2.14

URBAN AREA ACCIDENTS

Vehicle Weight < 3,000 lb
Primary Damage Area: Side
Impact Speed: >60 mph

FA
IA
PDA
F
I

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA				
IA				
PDA				
F	0	0	0	0
I	10	4	5	6

TABLE C.2.15

URBAN AREA ACCIDENTS

Vehicle Weight < 3,000 lb
Primary Damage Area: Rear
Impact Speed: 0-20 mph

FA
IA
PDA
F
I

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA				
IA				
PDA				
F	0	0	0	0
I	74	148	119	133

TABLE C.2.16

URBAN AREA ACCIDENTS

Vehicle Weight < 3,000 lb
Primary Damage Area: Rear
Impact Speed: 21-40 mph

FA
IA
PDA
F
I

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA				
IA				
PDA				
F	0	0	0	0
I	12	24	19	21

TABLE C.2.17

URBAN AREA ACCIDENTS

Vehicle Weight < 3,000 lb
Primary Damage Area: Rear
Impact Speed: 41-60 mph

FA
IA
PDA
F
I

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA				
IA				
PDA				
F	0	0	0	0
I	7	14	12	13

TABLE C.2.18

URBAN AREA ACCIDENTS

Vehicle Weight < 3,000 lb
Primary Damage Area: Rear
Impact Speed: >60 mph

FA
IA
PDA
F
I

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA				
IA				
PDA				
F	0	0	0	0
I	0	0	0	0

TABLE C.2.19

URBAN AREA ACCIDENTS

Vehicle Weight > 3,000 lb
Primary Demage Area: Front
Impact Speed: 0-20 mph

FA
IA
PDA
F
I

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA				
IA				
PDA				
F	11	11	5	36
I	2,748	1,303	628	11,024

TABLE C.2.20

URBAN AREA ACCIDENTS

Vehicle Weight > 3,000 lb
Primary Damage Area: Front
Impact Speed: 21-40 mph

FA
IA
PDA
F
I

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA				
IA				
PDA				
F	78	78	40	268
I	3,953	1,875	903	15,856

TABLE C.2.21

URBAN AREA ACCIDENTS

Vehicle Weight > 3,000 lb
Primary Damage Area: Front
Impact Speed: 41-60 mph

FA
IA
PDA
F
I

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA				
IA				
PDA				
F	88	88	46	301
I	1,329	630	304	5,330

TABLE C.2.22

URBAN AREA ACCIDENTS

Vehicle Weight > 3,000 lb
Primary Damage Area: Front
Impact Speed: >60 mph

FA
IA
PDA
F
I

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA				
IA				
PDA				
F	39	39	20	132
I	223	106	51	894

TABLE C.2.23

URBAN AREA ACCIDENTS

Vehicle Weight > 3,000 lb
Primary Damage Area: Side
Impact Speed: 0-20 mph

FA
IA
PDA
F
I

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA				
IA				
PDA				
F	0	0	0	0
I	657	298	343	478

TABLE C.2.24

URBAN AREA ACCIDENTS

Vehicle Weight > 3,000 lb
Primary Damage Area: Side
Impact Speed: 21-40 mph

FA
IA
PDA
F
I

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA				
IA				
PDA				
F	0	0	0	0
I	443	201	231	322

TABLE C.2.25

URBAN AREA ACCIDENTS

Vehicle Weight > 3,000 lb
Primary Damage Area: Side
Impact Speed: 41-60 mph

FA
IA
PDA
F
I

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA				
IA				
PDA				
F	0	0	0	0
I	140	64	73	102

TABLE C.2.26

URBAN AREA ACCIDENTS

Vehicle Weight > 3,000 lb
Primary Damage Area: Side
Impact Speed: >60 mph

FA
IA
PDA
F
I

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA				
IA				
PDA				
F	0	0	0	0
I	25	12	13	19

TABLE C.2.27

URBAN AREA ACCIDENTS

Vehicle Weight > 3,000 lb
Primary Damage Area: Rear
Impact Speed: 0-20 mph

FA
IA
PDA
F
I

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA				
IA				
PDA				
F	0	0	0	0
I	255	510	408	459

TABLE C.2.28

URBAN AREA ACCIDENTS

Vehicle Weight > 3,000 lb
Primary Damage Area: Rear
Impact Speed: 21-40 mph

FA
IA
PDA
F
I

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA				
IA				
PDA				
F	0	0	0	0
I	41	82	66	74

TABLE C.2.29

URBAN AREA ACCIDENTS

Vehicle Weight > 3,000 lb
Primary Damage Area: Rear
Impact Speed: 41-60 mph

FA
IA
PDA
F
I

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA				
IA				
PDA				
F	0	0	0	0
I	24	49	40	44

TABLE C.2.30

URBAN AREA ACCIDENTS

Vehicle Weight > 3,000 lb
Primary Damage Area: Rear
Impact Speed: >60 mph

FA
IA
PDA
F
I

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA				
IA				
PDA				
F	0	0	0	0
I	0	0	0	0

TABLE C.2.31

RURAL AREA ACCIDENTS

Vehicle Weight < 3,000 lb
Primary Damage Area: Front
Impact Speed: 0-20 mph

FA
IA
PDA
F
I

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA				
IA				
PDA				
F	17	17	9	60
I	1,336	634	305	5,358

TABLE C.2.32

RURAL AREA ACCIDENTS

Vehicle Weight < 3,000 lb
Primary Damage Area: Front
Impact Speed: 21-40 mph

FA
IA
PDA
F
I

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA				
IA				
PDA				
F	132	132	69	452
I	1,922	911	439	7,708

TABLE C.2.33

RURAL AREA ACCIDENTS

Vehicle Weight < 3,000 lb
Primary Damage Area: Front
Impact Speed: 41-60 mph

FA
IA
PDA
F
I

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA				
IA				
PDA				
F	146	146	77	506
I	646	306	147	2,591

TABLE C.2.34

RURAL AREA ACCIDENTS

Vehicle Weight < 3,000 lb
Primary Damage Area: Front
Impact Speed: >60 mph

FA
IA
PDA
F
I

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA				
IA				
PDA				
F	66	66	34	220
I	109	51	25	434

TABLE C.2.35

RURAL AREA ACCIDENTS

Vehicle Weight < 3,000 lb
Primary Damage Area: Side
Impact Speed: 0-20 mph

FA
IA
PDA
F
I

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA				
IA				
PDA				
F	92	69	57	63
I	759	344	396	552

TABLE C.2.36

RURAL AREA ACCIDENTS

Vehicle Weight < 3,000 lb
Primary Damage Area: Side
Impact Speed: 21-40 mph

FA
IA
PDA
F
I

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA				
IA				
PDA				
F	132	100	83	89
I	511	233	267	373

TABLE C.2.37

RURAL AREA ACCIDENTS

Vehicle Weight < 3,000 lb
Primary Damage Area: Side
Impact Speed: 41-60 mph

FA
IA
PDA
F
I

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA				
IA				
PDA				
F	89	66	57	60
I	162	74	85	118

TABLE C.2.38

RURAL AREA ACCIDENTS

Vehicle Weight < 3,000 lb
Primary Damage Area: Side
Impact Speed: >60 mph

FA
IA
PDA
F
I

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA				
IA				
PDA				
F	40	31	26	29
I	29	13	15	21

TABLE C.2.39

RURAL AREA ACCIDENTS

Vehicle Weight < 3,000 lb
Primary Damage Area: Rear
Impact Speed: 0-20 mph

FA
IA
PDA
F
I

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA				
IA				
PDA				
F	11	26	20	23
I	194	389	311	349

TABLE C.2.40

RURAL AREA ACCIDENTS

Vehicle Weight < 3,000 lb
Primary Damage Area: Rear
Impact Speed: 21-40 mph

FA
IA
PDA
F
I

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA				
IA				
PDA				
F	17	34	29	31
I	32	62	50	56

TABLE C.2.41

RURAL AREA ACCIDENTS

Vehicle Weight < 3,000 lb
Primary Damage Area: Rear
Impact Speed: 41-60 mph

FA
IA
PDA
F
I

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA				
IA				
PDA				
F	6	9	6	6
I	19	38	30	34

TABLE C.2.42

RURAL AREA ACCIDENTS

Vehicle Weight < 3,000 lb
Primary Damage Area: Rear
Impact Speed: >60 mph

FA
IA
PDA
F
I

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA				
IA				
PDA				
F	0	0	0	0
I	0	0	0	0

TABLE C.2.43

RURAL AREA ACCIDENTS

Vehicle Weight > 3,000 lb
Primary Damage Area: Front
Impact Speed: 0-20 mph

FA
IA
PDA
F
I

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA				
IA				
PDA				
F	26	26	14	89
I	5,903	2,800	1,350	23,681

TABLE C.2.44

RURAL AREA ACCIDENTS

Vehicle Weight > 3,000 lb
Primary Damage Area: Front
Impact Speed: 21-40 mph

FA
IA
PDA
F
I

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA				
IA				
PDA				
F	195	195	100	670
I	8,492	4,027	1,941	34,065

TABLE C.2.45

RURAL AREA ACCIDENTS

Vehicle Weight > 3,000 lb
Primary Damage Area: Front
Impact Speed: 41-60 mph

FA
IA
PDA
F
I

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA				
IA				
PDA				
F	217	217	112	750
I	2,854	1,354	652	11,450

TABLE C.2.46

RURAL AREA ACCIDENTS

Vehicle Weight > 3,000 lb
Primary Damage Area: Front
Impact Speed: >60 mph

FA
IA
PDA
F
I

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA				
IA				
PDA				
F	94	94	49	329
I	479	227	109	1,920

TABLE C.2.47

RURAL AREA ACCIDENTS

Vehicle Weight > 3,000 lb
Primary Damage Area: Side
Impact Speed: 0-20 mph

FA
IA
PDA
F
I

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA				
IA				
PDA				
F	94	72	60	63
I	2,521	1,145	1,315	1,833

TABLE C.2.48

RURAL AREA ACCIDENTS

Vehicle Weight > 3,000 lb
Primary Damage Area: Side
Impact Speed: 21-40 mph

FA
IA
PDA
F
I

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA				
IA				
PDA				
F	134	103	86	92
I	1,700	772	887	1,236

TABLE C.2.49

RURAL AREA ACCIDENTS

Vehicle Weight > 3,000 lb
Primary Damage Area: Side
Impact Speed: 41-60 mph

FA
IA
PDA
F
I

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA				
IA				
PDA				
F	92	69	57	63
I	540	245	281	392

TABLE C.2.50

RURAL AREA ACCIDENTS

Vehicle Weight > 3,000 lb
Primary Damage Area: Side
Impact Speed: >60 mph

FA
IA
PDA
F
I

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA				
IA				
PDA				
F	40	31	26	29
I	97	44	50	70

TABLE C.2.51

RURAL AREA ACCIDENTS

Vehicle Weight > 3,000 lb
Primary Damage Area: Rear
Impact Speed: 0-20 mph

FA
IA
PDA
F
I

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA				
IA				
PDA				
F	0	0	0	0
I	747	1,499	1,197	1,346

TABLE C.2.52

RURAL AREA ACCIDENTS

Vehicle Weight > 3,000 lb
Primary Damage Area: Rear
Impact Speed: 0-20 mph

FA
IA
PDA
F
I

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA				
IA				
PDA				
F	0	0	0	0
I	121	241	183	217

TABLE C.2.53

RURAL AREA ACCIDENTS

Vehicle Weight > 3,000 lb
Primary Damage Area: Rear
Impact Speed: 41-60 mph

FA
IA
PDA
F
I

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA				
IA				
PDA				
F	0	0	0	0
I	72	145	116	130

TABLE C.2.54

RURAL AREA ACCIDENTS

Vehicle Weight > 3,000 lb
Primary Damage Area: Rear
Impact Speed: >60 mph

FA
IA
PDA
F
I

	Cylindrical	Flat Breakaway	Flat Rigid	Other
FA				
IA				
PDA				
F	0	0	0	0
I	0	.0	0	0

APPENDIX D

1972 and 1985

MOTOR VEHICLE WITH PEDALCYCLE ACCIDENTS

FA: Fatal Accidents

IA: Injury Accidents

F: Fatalities

I: Injuries

TABLE D.1

URBAN AREA ACCIDENTS

FA	600
IA	74,800
F	600
I	78,400

Vehicle Weight < 3000 lb.

FA	125
IA	15,633
F	125
I	16,386

	Front	Side	Rear
FA	96	13	16
IA	11,991	1,641	2,001
F	96	13	16
I	12,568	1,721	2,097

Vehicle Weight > 3000 lb.

FA	475
IA	59,167
F	475
I	62,014

	Front	Side	Rear
FA	366	73	36
IA	45,618	9,112	4,438
F	366	73	36
I	47,813	9,550	4,651

TABLE D.2

RURAL AREA ACCIDENTS

FA	500
IA	18,700
F	500
I	19,600

Vehicle Weight < 3000 lb.

FA	129
IA	4,825
F	129
I	5,057

	Front	Side	Rear
FA	114	10	5
IA	4,256	382	188
F	114	10	5
I	4,460	400	197

Vehicle Weight > 3000 lb.

FA	371
IA	13,875
F	371
I	14,543

	Front	Side	Rear
FA	311	45	15
IA	11,631	1,693	569
F	311	45	15
I	12,172	1,774	596

TABLE D.3

1972

URBAN AREA ACCIDENTS
Vehicle Weight < 3000 lb.
Primary Collision Area: Front

FA	96
IA	11,991
F	96
I	12,568

Impact Speed:	0-20 MPH	21-40	> 40
FA	38	48	9
IA	7,015	4,856	120
F	38	48	9
I	7,352	5,090	126

TABLE D.4

1972

URBAN AREA ACCIDENTS
Vehicle Weight < 3000 lb.
Primary Collision Area: Side

FA	13
IA	1,641
F	13
I	1,721

Impact Speed:	0-20 MPH	21-40	> 40
FA	5	6	1
IA	960	665	16
F	5	6	1
I	1,007	697	17

TABLE D.5

1972

URBAN AREA ACCIDENTS
Vehicle Weight < 3000 lb.
Primary Collision Area: Rear

FA	16
IA	2,001
F	16
I	2,097

Impact Speed:	0-20 MPH	21-40	> 40
FA	16	0	0
IA	2,001	0	0
F	16	0	0
I	2,097	0	0

TABLE D.6

1972

URBAN AREA ACCIDENTS
Vehicle Weight > 3000 lb.
Primary Collision Area: Front

FA	366
IA	45,618
F	366
I	47,813

Impact Speed:	0-20 MPH	21-40	> 40
FA	146	182	38
IA	26,687	18,475	456
F	146	182	38
I	27,971	19,364	478

TABLE D.7

1972

URBAN AREA ACCIDENTS
Vehicle Weight > 3000 lb.
Primary Collision Area: Side

FA	73
IA	9,112
F	73
I	9,550

Impact Speed:	0-20 MPH	21-40	40
FA	29	36	8
IA	5,331	3,690	91
F	29	36	8
I	5,587	3,868	96

TABLE D.8

URBAN AREA ACCIDENTS
Vehicle Weight > 3000 lb.
Primary Collision Area: Rear

FA	36
IA	4,438
F	36
I	4,651

Impact Speed:	0-20 MPH	21-40	>40
FA	36	0	0
IA	4,438	0	0
F	36	0	0
I	4,651	0	0

TABLE D.9

1972

RURAL AREA ACCIDENTS
Vehicle Weight < 3000 lb.
Primary Collision Area: Front

FA	114
IA	4,256
F	114
I	4,460

Impact Speed:	0-20 MPH	21-40	> 40
FA	47	57	12
IA	2,490	1,724	43
F	47	57	12
I	2,609	1,806	45

TABLE D.10

1972

RURAL AREA ACCIDENTS
Vehicle Weight < 3000 lb.
Primary Collision Area: Side

FA	10
IA	382
F	10
I	400

Impact Speed:	0-20 MPH	21-40	> 40
FA	4	5	1
IA	223	155	4
F	4	5	1
I	234	162	4

TABLE D.11

1972

RURAL AREA ACCIDENTS
Vehicle Weight < 3000 lb.
Primary Collision Area: Rear

FA	5
IA	188
F	5
I	197

Impact Speed:	0-20 MPH	21-40	> 40
FA	5	0	0
IA	188	0	0
F	5	0	0
I	197	0	0

TABLE D.12

1972

RURAL AREA ACCIDENTS
Vehicle Weight > 3000 lb
Primary Collision Area: Front

FA	311
IA	11,613
F	311
I	12,172

Impact Speed:	0-20 MPH	21-40	> 40
FA	124	155	32
IA	6,794	4,703	116
F	124	155	32
I	7,121	4,930	121

TABLE D.13

1972

RURAL AREA ACCIDENTS
Vehicle Weight > 3000 lb.
Primary Collision Area: Side

FA	45
IA	1,693
F	45
I	1,774

Impact Speed:	0-20 MPH	21-40	> 40
FA	18	22	5
IA	990	686	17
F	18	22	5
I	1,038	718	18

TABLE D.14

1972

RURAL AREA ACCIDENTS
Vehicle Weight > 3000 lb.
Primary Collision Area: Rear

FA	15
IA	569
F	15
I	596

Impact Speed:	0-20 MPH	21-40	> 40
FA	15	0	0
IA	569	0	0
F	15	0	0
I	596	0	0

TABLE D.15

URBAN AREA ACCIDENTS
1985

FA	676
IA	72,565
F	676
I	76,194

Vehicle Weight < 3000 lb.

FA	169
IA	17,416
F	169
I	18,287

	Front	Side	Rear
FA	130	18	22
IA	13,358	1,829	2,229
F	130	18	22
I	14,026	1,920	2,341

Vehicle Weight > 3000 lb.

FA	507
IA	55,149
F	507
I	57,907

	Front	Side	Rear
FA	390	78	38
IA	42,520	8,492	4,136
F	390	78	38
I	44,646	8,918	4,343

TABLE D.16

RURAL AREA ACCIDENTS
1985

FA	414
IA	14,863
F	414
I	15,606

Vehicle Weight < 3000 lb.

FA	124
IA	4,310
F	124
I	4,526

	Front	Side	Rear
FA	109	10	5
IA	3,801	340	168
F	109	10	5
I	3,992	358	177

Vehicle Weight > 3000 lb.

FA	290
IA	10,553
F	290
I	11,080

	Front	Side	Rear
FA	243	35	12
IA	8,833	1,287	433
F	243	35	12
I	9,274	1,352	454

TABLE D.17

1985

URBAN AREA ACCIDENTS
Vehicle Weight < 3000 lb.
Primary Collision Area: Front

FA	130
IA	13,358
F	130
I	14,026

Impact Speed:	0-20 MPH	21-40	> 40
FA	52	65	13
IA	7,814	5,410	134
F	52	65	13
I	8,205	5,681	140

TABLE D.18

1985

URBAN AREA ACCIDENTS
Vehicle Weight < 3000 lb.
Primary Collision Area: Side

FA	18
IA	1,829
F	18
I	1,920

Impact Speed:	0-20 MPH	21-40	> 40
FA	7	9	2
IA	1,070	741	18
F	7	9	2
I	1,123	778	19

TABLE D.19

1985

URBAN AREA ACCIDENTS
Vehicle Weight < 3000 lb.
Primary Collision Area: Rear

FA	22
IA	2,229
F	22
I	2,341

Impact Speed:	0-20 MPH	21-40	40
FA	22	0	0
IA	2,229	0	0
F	22	0	0
I	2,341	0	0

TABLE D.20

1985

URBAN AREA ACCIDENTS
Vehicle Weight > 3000 lb.
Primary Collision Area: Front

FA	390
IA	42,520
F	390
I	44,646

Impact Speed:	0-20 MPH	21-40	> 40
FA	156	194	40
IA	24,874	17,221	425
F	156	194	40
I	26,118	18,082	446

TABLE D.21

1985

URBAN AREA ACCIDENTS
Vehicle Weight > 3000 lb.
Primary Collision Area: Side

FA	78
IA	8,492
F	78
I	8,918

Impact Speed:	0-20 MPH	21-40	40
FA	31	39	8
IA	4,968	3,439	85
F	31	39	8
I	5,217	3,612	89

TABLE D.22

1985

URBAN AREA ACCIDENTS
Vehicle Weight > 3000 lb.
Primary Collision Area: Rear

FA	38
IA	4,136
F	38
I	4,343

Impact Speed:	0-20 MPH	21-40	40
FA	38	0	0
IA	4,136	0	0
F	38	0	0
I	4,343	0	0

TABLE D.23

1985

RURAL AREA ACCIDENTS
Vehicle Weight < 3000 lb.
Primary Collision Area: Front

FA	109
IA	3,801
F	109
I	3,992

Impact Speed:	0-20 MPH	21-40	>40
FA	44	54	11
IA	2,224	1,539	38
F	44	54	11
I	2,335	1,617	40

TABLE D.24

1985

RURAL AREA ACCIDENTS
Vehicle Weight < 3000 lb.
Primary Collision Area: Side

FA	10
IA	340
F	10
I	358

Impact Speed:	0-20 MPH	21-40	>40
FA	4	5	1
IA	199	138	3
F	4	5	1
I	209	145	4

TABLE D.25

1985

RURAL AREA ACCIDENTS
Vehicle Weight < 3000 lb.
Primary Collision Area: Rear

FA	5
IA	168
F	5
I	177

Impact Speed:	0-20 MPH	21-40	> 40
FA	5	0	0
IA	168	0	0
F	5	0	0
I	177	0	0

TABLE D.26

1985

RURAL AREA ACCIDENTS
Vehicle Weight > 3000 lb.
Primary Collision Area: Front

FA	243
IA	8,833
F	243
I	9,274

Impact Speed:	0-20 MPH	21-40	> 40
FA	97	121	25
IA	5,167	3,577	88
F	97	121	25
I	5,425	3,756	93

TABLE D.27

1985

RURAL AREA ACCIDENTS
Vehicle Weight > 3000 lb.
Primary Collision Area: Side

FA	35
IA	1,287
F	35
I	1,352

Impact Speed:	0-20 MPH	21-40	40
FA	14	17	4
IA	753	521	13
F	14	17	4
I	791	548	14

TABLE D.28

1985

RURAL AREA ACCIDENTS
Vehicle Weight > 3000 lb.
Primary Collision Area: Rear

FA	12
IA	433
F	12
I	454

Impact Speed:	0-20 MPH	21-40	> 40
FA	12	0	0
IA	433	0	0
F	12	0	0
I	454	0	0

APPENDIX E

1972 and 1985

MOTOR VEHICLE ROLLOVER ACCIDENTS

FA: Fatal Accidents

IA: Injury Accidents

PDA: Property Damage Accidents

F: Fatalities

I: Injuries

TABLE E.1

1972

URBAN AREA ACCIDENTS
by Vehicle Weight and Speed Prior to Impact

FA	680
IA	20,520
PDA	3,740
F	740
I	28,730

Vehicle Weight < 3000 lb.

FA	306
IA	9,234
PDA	1,683
F	333
I	12,929

	0-30 MPH	>30 MPH
FA	11	295
IA	342	8,892
PDA	62	1,621
F	12	321
I	478	12,451

Vehicle Weight > 3000 lb.

FA	374
IA	11,286
PDA	2,057
F	407
I	15,801

	0-30 MPH	>30 MPH
FA	14	360
IA	418	10,868
PDA	76	1,981
F	15	392
I	585	15,216

TABLE E.2

1972

RURAL AREA ACCIDENTS
by Vehicle Weight and Speed Prior to Impact

FA	3,020
IA	42,465
PDA	8,030
F	3,365
I	65,750

Vehicle Weight < 3000 lb.

DA	1,359
IA	19,109
PDA	3,614
F	1,514
I	29,588

	0-30 MPH	>30 MPH
FA	50	1,309
IA	707	18,402
PDA	134	3,480
F	56	1,458
I	1,095	28,493

Vehicle Weight > 3000 lb.

FA	1,661
IA	23,356
PDA	4,416
F	1,851
I	36,162

	0-30 MPH	>30 MPH
FA	61	1,600
IA	864	22,492
PDA	163	4,253
F	68	1,783
I	1,338	34,824

TABLE E.3

1985

URBAN AREA ACCIDENTS
by Vehicle Weight and Speed Prior to Impact

FA	847
IA	25,178
PDA	4,582
F	921
I	35,252

Vehicle Weight < 3000 lb.

FA	381
IA	11,330
PDA	2,062
F	414
I	15,864

	0-30 MPH	>30 MPH
FA	14	367
IA	420	10,910
PDA	76	1,986
F	15	399
I	587	15,277

Vehicle Weight > 3000 lb.

FA	466
IA	13,848
PDA	2,520
F	507
I	19,388

	0-30 MPH	>30 MPH
FA	17	449
IA	512	13,335
PDA	93	2,427
F	19	488
I	718	18,670

TABLE E.4

1985

RURAL AREA ACCIDENTS
by Vehicle Weight and Speed Prior to Impact

FA	3,760
IA	52,105
PDA	9,837
F	4,189
I	80,675

Vehicle Weight < 3000 lb.

FA	1,692
IA	23,447
PDA	4,427
F	1,885
I	36,304

	0-30 MPH	>30 MPH
FA	62	1,630
IA	863	22,579
PDA	164	4,263
F	70	1,815
I	1,343	34,961

Vehicle Weight > 3000 lb.

FA	2,068
IA	28,658
PDA	5,410
F	2,304
I	44,371

	0-30 MPH	>30 MPH
FA	76	1,992
IA	1,060	27,598
PDA	200	5,210
F	84	2,220
I	1,642	42,729

APPENDIX F

1972 and 1985

MOTORCYCLE ACCIDENTS WITH MOTOR VEHICLES

FA: Fatal Accidents

IA: Injury Accidents

TABLE F.1

MOTORCYCLE ACCIDENTS WITH MOTOR VEHICLES

1972-1985

Total

	1972	1985
FA:	1,755	2,685
IA:	61,425	93,990

	Urban 1972	Urban 1985	Rural 1972	Rural 1985
FA:	585	894	1,170	1,791
IA:	30,713	46,995	30,713	46,995

	Urban Day 1972	Urban Day 1985	Urban Night 1972	Urban Night 1985	Rural Day 1972	Rural Day 1985	Rural Night 1972	Rural Night 1985
FA:	390	596	195	298	780	1,196	390	595
IA:	20,485	31,346	10,227	15,649	20,485	31,346	10,227	15,649

TABLE F.2

1972

URBAN AREA

FA: 585

IA: 30,713

	Front of Car Impacts Motorcycle	Motorcycle Impacts Side of Car	Motorcycle Impacts Rear of Car
FA:	340	212	33
IA:	17,875	11,118	1,720

TABLE F.3

1972

RURAL AREA

FA: 1,170

IA: 30,713

	Front of Car Impacts Motorcycle	Motorcycle Impacts Side of Car	Motorcycle Impacts Rear of Car
FA:	681	424	66
IA:	17,875	11,118	1,720

TABLE F.4

1985

URBAN AREA

FA: 894

IA: 46,995

	Front of Car Impacts Motorcycle	Motorcycle Impacts Side of Car	Motorcycle Impacts Rear of Car
FA: 520	520	324	50
IA:	27,351	17,012	2,632

TABLE F.5

1985

FA: 1,791

IA: 46,995

	Front of Car Impacts Motorcycle	Motorcycle Impacts Side of Car	Motorcycle Impacts Rear of Car
FA:	1,042	648	100
IA:	27,351	17,012	2,632

TABLE F.6

1972

URBAN AREA

FRONT OF CAR IMPACTS MOTORCYCLE

FA: 340

IA: 17,875

Impact Speed:	0-20 MPH	21-40	41-60	>60
FA:	92	84	114	50
IA:	4,862	4,415	5,988	2,610

TABLE F.7

1972

URBAN AREA

MOTORCYCLE IMPACTS SIDE OF CAR

FA: 212

IA: 11,118

Impact Speed:	0-20 MPH	21-40	41-60	>60
FA:	8	82	82	40
IA:	445	4,292	4,292	2,090

TABLE F.8

1972

URBAN AREA

MOTORCYCLE IMPACTS REAR OF CAR

FA: 33

IA: 1,720

Impact Speed:	0-20 MPH	21-40	41-60	>60
FA:	2	12	14	5
IA:	122	614	738	246

TABLE F.9

1972

RURAL AREA

FRONT OF CAR IMPACTS MOTORCYCLE

FA: 681

IA: 17,875

Impact Speed:	0-20 MPH	21-40	41-60	>60
FA:	185	168	228	99
IA:	4,862	4,415	5,988	2,610

TABLE F.10

1972

RURAL AREA

MOTORCYCLE IMPACTS SIDE OF CAR

FA: 424

IA: 11,118

Impact Speed:	0-20 MPH	21-40	41-60	>60
FA:	17	164	164	79
IA:	444	4,292	4,292	2,090

TABLE F.11

1972

RURAL AREA

MOTORCYCLE IMPACTS REAR OF CAR

FA: 66

IA: 1,720

Impact Speed:	0-20 MPH	21-40	41-60	> 60
FA:	5	24	28	9
IA:	122	614	738	246

TABLE F.12

1985
URBAN AREA

FRONT OF CAR IMPACTS MOTORCYCLE

FA: 520

IA: 27,351

Impact Speed:	0-20 MPH	21-40	41-60	>60
FA:	141	128	174	76
IA:	7,439	6,756	9,163	3,993

TABLE F.13

1985

URBAN AREA

MOTORCYCLE IMPACTS SIDE OF CAR

FA: 324

IA: 17,012

Impact Speed:	0-20 MPH	21-40	41-60	> 60
FA:	13	125	125	61
IA:	680	6,567	6,567	3,198

TABLE F.14

1985

URBAN AREA

MOTORCYCLE IMPACTS REAR OF CAR

FA: 50

IA: 2,632

Impact Speed:	0-20 MPH	21-40	41-60	>60
FA:	4	18	21	7
IA:	187	940	1,129	376

TABLE F.15

1985

RURAL AREA

FRONT OF CAR IMPACTS MOTORCYCLE

FA: 1,042

IA: 27,351

Impact Speed:	0-20 MPH	21-40	41-60	>60
FA:	283	257	349	152
IA:	7,439	6,756	9,163	3,993

TABLE F.16

1985

RURAL AREA

MOTORCYCLE IMPACTS SIDE OF CAR

FA: 648

IA: 17,012

Impact Speed:	0-20 MPH	21-40	41-60	>60
FA:	26	250	250	122
IA:	680	6,567	6,567	3,198

TABLE F.17

1985

RURAL AREA

MOTORCYCLE IMPACTS REAR OF CAR

FA: 100
IA: 2,632

Impact Speed:	0-20 MPH	21-40	41-60	> 60
FA:	7	36	43	14
IA:	187	940	1,129	376